

COMBUSTION

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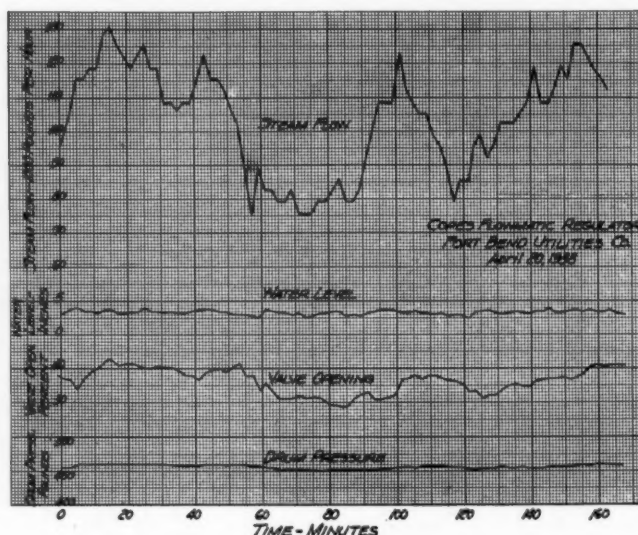


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EDITORIAL

Coal Mixtures vs. Ash-Softening Temperatures

With many modern steam generating units ash-softening temperature is an important factor. This is especially true where high steam temperatures are employed, for the gases must leave the furnace at a temperature sufficiently high to provide the desired superheat yet they must be kept under the fusing temperature of the ash in order to avoid slagging of the boiler tubes. Also, where a slagging-bottom furnace is employed it is desirable that the ash-fusing temperature be relatively low in order to insure fluidity at light loads.

If predicted operating conditions are followed and a coal of constant known characteristics is burned, it is comparatively easy to design a unit to meet the prescribed conditions without troublesome slagging, providing the design is basically sound. However, because of unforeseen conditions, operation does not always follow along the lines contemplated and all too frequently coals are burned that are far different from those anticipated. Many users secure their coal supply from more than one source, or where it is purchased from one producer it may come from several mines. The result is that it is mixed in varying proportions by the time it reaches the furnace. Such mixing has a marked effect on the ash-softening temperature and often upsets predictions upon which the furnace calculations were based.

At best, coal ash has a complex composition and the oxides of silicon, aluminum, iron and calcium are known to directly affect the ash-softening temperature, particularly when the proportions in which they are combined are varied.

One might expect that where two coals are mixed in equal proportions the softening temperature of the ash resulting from the mixture would be the mean of their respective softening temperatures. This, while possible, is not usually the case. In some mixtures this temperature may be raised and in others it may be greatly depressed below the theoretical mean, these relations being further affected by the proportions. The situation is analogous to that of certain metals, notably tin and lead, which when combined have a melting point far different from those of the original metals.

Where certain coals are to be mixed in definite proportions the simplest procedure would be to test the ash for softening temperature from a sample of the mixture, but where the proportions are not constant and the coals vary this entails considerable laboratory work. Furthermore, where it is aimed to produce certain results such a method involves much experimentation to determine the proper proportions.

Several years ago this subject was investigated very thoroughly at Carnegie Institute of Technology under the direction of the Mining and Metallurgical Advisory Boards. As a result of these studies with one hundred and eighty mixtures a series of charts was evolved from which it is possible to predict, with reasonable accuracy,

the softening temperature of the ash from the mixture, based upon an analysis of the individual coals. These charts and the supporting data were made available in pamphlet form in 1934. To what extent this information has been disseminated and is being used in current operation is not known, but it is suggested that those confronted with slagging problems due to uncertain ash-softening temperatures would find it most helpful.

Power and National Defense

Coincident with the current tense situation in Europe comes an announcement from Washington that the President has appointed a special committee to study and report on an industrial mobilization plan for power to the end that certain strategic manufacturing centers and cities shall have dual supplies of power, one of which in each case shall be from an outside source. The committee is made up of representatives from the War, Navy and Interior Departments, the Federal Power Commission, the Securities and Exchange Commission, the National Resources Board, the Reconstruction Finance Corporation, the TVA and certain other Federal power bodies. No mention is made of representatives of the utilities which necessarily must play the major role in such a cooperative plan.

Assistant Secretary of the Navy, Charles A. Edison, a member of the committee, is reported as commenting that the private utilities are three years behind their normal growth in capacity and that it is now very necessary that they catch up.

In connection with the formation of the committee reference has been made to the situation that obtained during the World War when a shortage of power in several industrial communities threatened to curtail seriously the production of munitions. However, it must be remembered that at that time very little interconnection existed between the systems of individual power companies. Shortly after the War the Superpower Survey was initiated with the object of effecting an integrated system of power supply along the North Atlantic seaboard. This pointed the way to the subsequent extensive interconnection of systems not only in that region but other sections of the country as well, although the Middle West had already begun such a program. Predicated upon the economical exchange of power, the curtailment of reserve capacity and the insurance of continuity of service, such interconnection was carried on solely by private initiative.

Some may question the necessity of appointing a special committee at this time to make such a study of power supply when the ground has already been covered very thoroughly by the U. S. Army Engineers and the Army's Industrial College, both of whose surveys are kept up to date. Perhaps the ultimate aim is to set up a grid that will provide an outlet for power from various Federal hydro projects and offer an additional excuse for St. Lawrence development, under the guise of national defense to which public reaction is always favorable.

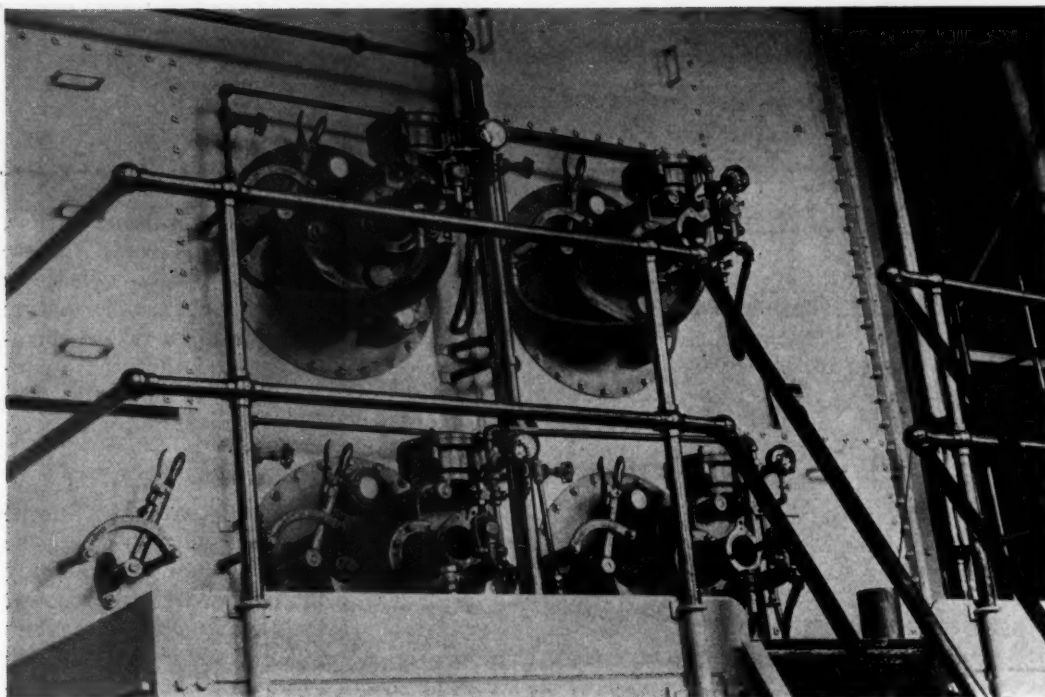


Fig. 1—Combination burners were initially installed in the boilers of this industrial plant; pulverizing equipment to be installed when conditions warrant

Combination Oil and Pulverized Coal Burning

The adaptability of pulverized coal furnaces to oil burning is discussed and reference is made to the proper type of air register to prevent the high velocity air from depositing slugs of unvaporized oil on the furnace walls. The desirability of combination firing to take advantage of current fuel prices and of oil as a supplementary fuel for light load periods, starting up and for insurance of ignition with interruption of coal feed is stressed. Mechanical versus steam atomization is discussed with reference to the adaptability and limitations of each and information is given on the proper pressures and temperatures to be employed.

RECENT practice, particularly in industrial plants, has indicated a strong trend toward equipping pulverized coal burning units with oil as an auxiliary fuel. The two fuels supplement each other very well. Both are finely divided fuels, burned in suspension, the coal being pulverized and the oil atomized either mechanically by pressure only or by the use of steam or air as the atomizing agent. A furnace designed primarily for pulverized coal always has ample volume for burning oil and the usual water-cooled walls and slag screens are ideal for getting the greatest benefit from the radiant heat of the oil flame. The same fans, air preheaters, etc., can be used for both.

By **KINGSLEY L. MARTIN**, President
The Engineer Company, New York

Effect of Air Register Design

The crux of the problem is the air register. It was at first assumed that of the two fuels, coal was the more difficult to burn and any conditions that were suitable for coal would do for oil. To a certain extent, this has been found to be true as oil has been successfully burned in corner-fired furnaces and in intertube burners where there is no nearby refractory present to help ignition and raise the flame temperature. In such cases the conventional rotation of the air, the use of diffuser cones, etc., previously thought indispensable, have been eliminated.

With the more usual register-type of circular burner having vanes to give rotation to the air, a refractory throat and a central coal pipe with the customary small ignition tube located in the center, it has been found entirely possible to design a combination unit that will give a wide range in capacity and high efficiency with either fuel. It has also been found that whatever improves results with one fuel is also better for the other.

However, the register may be so designed that, while giving acceptable results with coal, the incoming air will strike the oil spray in such a way and at such velocity as to tear the flame apart and throw the oil on the floor and the side walls of the furnace, thus filling the furnace with large drops of flaming oil. This result is frequently attributed to poor atomization but that this is not the cause is shown by the fact that the same atomizers in other types of registers or in the same registers when

modified, give excellent results. Although the oil issues from the atomizer in a very fine spray or mist, it is nevertheless composed of very fine globules of solid oil. These catch fire and burn from the outside in, but have, for a time, a liquid center. In a very short time, probably less than a hundredth of a second, all the oil is consumed and converted into a flaming white hot gas and in this condition it may safely be struck by high velocity air and combustion is completed normally.

If, however, the high velocity air strikes the burning spray while it is still composed of burning liquid drops, the small drops coalesce into bigger ones which are blown like rain onto the furnace walls or floor and build up carbon. They also form large flaming drops which burn in suspension.

This result is more marked with mechanical atomizers than with steam as the spray from the latter seems to be

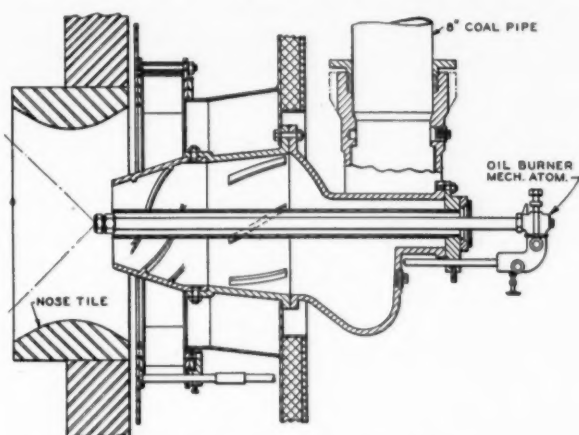


Fig. 2—Typical combination burner

more finely atomized and burns out quicker, and the action of the steam seems to stiffen the flame against distortion by the air. In any event, steam atomizers have repeatedly proved satisfactory where mechanical types did not.

To protect the spray from the high velocity air until ignition is well established, some form of shield is usual, the action being similar to that of a man who cups his hands around a match. In the conventional oil burner, this function is performed by a diffuser cone, but in the combination burner, the use of the cone is generally impractical as it would be located in the furnace end of the coal pipe and be very much in the way when changing quickly to coal. In the earlier installations, a cone was used with provision for withdrawing it by employing a recess in the burner head, but experience proved that it was possible to use the coal pipe itself, either of the cylindrical or cone type for this purpose, particularly as the primary air is not normally used in burning oil.

It should be noted, however, that some units take a large proportion of the air for combustion, say forty to sixty per cent, through the pulverizer, all of which enters through the coal pipe as primary air, the balance of the required air entering through the small annular space around the coal pipe past vanes which give it a rotary motion. In this type, when the mill is shut down, the secondary air alone cannot maintain full steaming capacity with oil; first, because the secondary fan is not large enough; second, because the residual register area is not adequate; and third, distribution of air to the flame is not correct.

In the majority of pulverized coal installations, however, only a small portion of the total air required goes through the mill and the secondary air fan readily supplies the difference when the mill is shut down; hence the distribution is effective.

The routine, then, of changing from coal to oil is to turn on the oil in one burner at a time and the oil spray lights from the coal flame. The coal to this burner is shut off, the pipe being scavenged of loose coal. This is important. The secondary air supply is readjusted to the new conditions and the next burner is then changed over in the same way. A boiler generating 600,000 lb of steam per hour at 650 lb pressure has been changed from oil to coal and back again twice a month for over a year without losing a pound of steam output or pressure and without a dollar of expense or time lost by boiler outage.

Where Alternate Fuels Are Desirable

Where the fuel costs are apparently equal or fluctuate so that sometimes one fuel and sometimes the other is preferable, the ability to use either fuel has its advantages from a bargaining point for the purchasing agent and from an operating point for the chief engineer.

As an example, a large utility company had an advantageous long term oil contract which made it advisable to burn all the oil the contract would allow. Of its four plants burning oil in whole or in part, three would have required expensive furnace changes every time a fuel change was made. The fourth was equipped to burn pulverized coal and oil. This plant was therefore kept on coal for two weeks until the amount of oil remaining available for the month was known and this amount was shipped and burned. This plan resulted in a very material saving. Again, the closing of navigation in the river by ice prevented this plant, while running on oil, from getting its usual barge load deliveries and it was shifted to and kept on coal until the ice went out.

In some cases, there may be little likelihood of burning coal in the near future, but a possibility. Such plants often find it advantageous to install combination pulverized coal and oil burners at the time the boilers are installed, deferring the purchase of mills, hoppers, piping, etc., until ready to burn coal. The necessary equipment can be installed, connected to the burners and put in service with at most a slight interruption of operation and with no cost for furnace changes.

Operation at Light Loads and in Warming Up

For plants that start and expect to continue indefinitely on coal, auxiliary oil equipment is desirable for several reasons. Pulverized coal does not lend itself so readily to operation at low capacities and most of the troubles in maintaining ignition and from unstable furnace conditions occur when the boiler is being warmed up and put on the line. It is desirable to warm up modern steam generating units slowly and allow plenty of time for the expansion of the boiler and setting. Because of the difficulties inherent in maintaining the right fuel mixture and getting proper turbulence and flame conditions in a coal furnace at low capacity, it is difficult to bring a boiler up to pressure slowly and evenly.

Having oil available, as much or as little heat may be developed in the furnace as desired and the boiler brought on the line in any time specified with stable furnace conditions. When the furnace has become hot, the setting

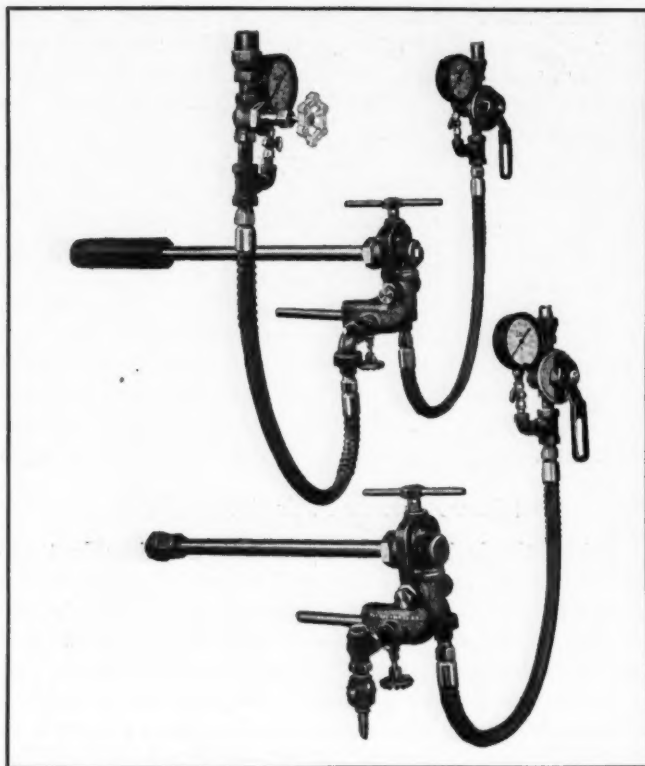


Fig. 3—Interchangeable burner with steam and mechanical atomizers

thoroughly warmed up and the boiler steaming, then the coal is turned on and a reduced oil flame kept burning until the flow of coal through the bunkers, chutes, mills and piping is well established and stable ignition and burning assured.

Oil as a Safeguard against Interruption

Another advantage is the safeguarding against interruption in steam output and possible plant shut down. It is well known that there is only a few seconds supply of fuel in a pulverized coal furnace and any interruption in the supply due to coal hanging up in the chutes, mill stoppage from mechanical or electrical reasons or any other cause, will result in instant loss of ignition. The plant keeps on pulling steam and the pressure goes down rapidly. In one large plant, it sank from 450 lb to 125 lb in a minute and a half. This condition exists where, as is frequently the case nowadays, the whole plant load is carried on one large pulverized coal boiler.

To meet this situation, many plants install an oil heating and pumping system which is under automatic control, both as to oil pressure and temperature. Hot oil is kept circulating slowly past the burners in service and oil atomizers are maintained connected but withdrawn in the ignition tubes to clear the coal flames. On failure of coal ignition, the atomizers are shoved into place, a torch is inserted and on turning one or two valves, admitting oil and atomizing steam, if used, the load can be picked up instantly and steam pressure restored and maintained. The time required is that necessary to light a torch and stick it in.

It is also considered good practice in some plants, to keep the oil burning continuously at a low rate to act as a pilot light to the pulverized coal flame. In many small industrial plants, the operating force have duties which prevent their giving continuous attention to the burners. If ignition is lost for any reason, pulverized coal continues

to pour into the furnace and if ignited by hot brickwork or incandescent carbon may cause a violent puff with possible damage to the boiler setting. The small hot oil flame at the end of the coal pipe would prevent this by reigniting the coal stream as soon as flow is reestablished.

It should be understood that these measures for the use of oil to safeguard output must be backed up by the installation of a well designed oil heating and pumping system that will respond instantly and automatically to the opening of the oil fuel valves at the burners with sufficient hot oil at the proper pressure to meet any demand.

Complete loss of steam has resulted in some cases, especially where there is considerable process work, in a cost, due to clearing vats, mixers, etc., of material, in loss of material spoiled and in loss of production of from five to one hundred thousand dollars.

Still another advantage, becoming more common with the spread of the forty-hour week, is ability to carry the week-end load easily and economically. In one metal working plant, in summer, there is practically no load whatever from Friday night to Monday morning, yet to meet insurance requirements, at least 100 lb steam pressure must be carried at all times with ability to pick up instantly and carry the load of fire pumps. The plant, in winter, operates most economically on pulverized coal. In summer, the normal load is so small that one of the two coal burners is equipped with a steam atomizing burner which develops about 12,000 lb of steam per hour on natural draft, the forced- and induced-draft fans being shut down, thus effecting quite a saving, as the current to run them is purchased. Over week-ends, the oil burner is run at low capacity, just sufficient to maintain pressure and an output of not more than 300 lb of steam per hour. This requires only about four gallons of oil an hour. As the capacity of the boiler is 65,000 lb an hour, this gives the maximum in flexibility which would be impossible with coal alone.

Steam vs. Mechanical Atomization

Much has been said and written about the relative merits of steam and mechanical atomization of the oil. Interchangeable steam and mechanical atomizing guns which can be quickly substituted for each other on the same burner support are now in use, see Fig. 3. Both types have the same efficiency of combustion. Each has its advantages and its limitations. The choice, then, becomes a matter of operating conditions and engineering judgment. Some plants use both types to meet varying conditions, as the shift of size or type of gun can be made quickly and easily.

Mechanical atomizers are best suited for steady loads and high capacity, but because of the small diameter of the orifice and passages through the sprayer plate, they are not adapted to carrying low loads in large units, as they will drool and carbonize. Moreover, with only one or two burners to a furnace, it is difficult to carry a swinging load efficiently, as it is necessary frequently to change sprayer plates to obtain good atomization at different ratings, and it is further quite possible to get caught with small sprayer plates in the burner with a rapidly increasing load.

Steam atomizing burners are best suited to swinging loads, difficult draft conditions, cold furnaces and for standby service. They give better results than the

mechanical burners in emergencies and for very low loads, as the fineness of atomization is maintained at all loads and the burner remains lighted under all conditions. However, they use about 1.2 per cent of the steam generated to atomize the oil and this is undesirable, under some plant conditions, for continuous operation.

Sometimes it is desirable to carry the heavy loads on mechanical atomizers, using the steam atomizers for lighting when changing to coal, for low loads, for banking loads, for week-ends, etc., and for emergency operation on failure of coal supply for any reason.

To bring a cold boiler on the line, the steam atomizer is undeniably best, especially if compressed air (from the scavenging hose) is available at about 50 lb pressure. The flame is steady and burns clearly even in a cold furnace and the mechanical atomizers or pulverized coal can be started without smoke after the furnace is hot.

Oil Temperatures and Pressures

Inquiries are frequently made as to what oil temperatures and pressures should be used and a word of explanation would seem to be in order. It should be understood that the only purpose of heating the oil is to reduce its viscosity, or in other words, increase its fluidity. The lighter oils require no heat for either pumping or atomizing. The heavier oils, generally called Bunker "C", require heating to reduce their viscosity.

The viscosity is usually expressed in terms of seconds Saybolt Furol or Universal, which simply means the time required by a measured sample of oil at a specified temperature, usually 122 F, to run through an orifice. For pumping from cars or barges to storage tanks and from storage tanks to the oil heaters on the pump set, a viscosity of 700 sec Saybolt Furol is customary. This requires a temperature of about 100 F. For steam atomization, a viscosity of 40 sec Saybolt Furol is advisable and is obtained generally at 185 F. For mechanical atomization, a still lower viscosity, below the Furol scale, is necessary and is specified as 150 sec Saybolt Universal, which usually requires 220 F. Heating above 220 F is likely, with many commercial fuel oils, to cause trouble from carbon and sludge accumulation in the heaters.

It should also be borne in mind, however, that the cracking processes developed by the oil refineries are producing very excellent heavy oils which, contrary to general impression, are quite liquid and may require heating to only 150 F, even for mechanical atomization and if inadvertently heated to ordinary temperatures, will drop solids out of suspension and clog up the oil heaters.

As to pressures at the atomizers, there is a wide range, depending on conditions. For steam atomizing, the only function of the oil pressure is to deliver a sufficient quantity of oil to the burner, and the steam atomizes it equally well at all capacities. The oil pressure may, therefore, vary from about two pounds at minimum capacity to 100 or 125 lb at the maximum.

With mechanical atomizers the pressure alone must atomize the oil; the higher the pressure, the finer the atomization. Generally, 250 lb maximum is sufficient and keeps the cost of pumps, heaters, valves and fittings in the lower brackets. If, however, a wide range in capacity without changing sprayer plates is desired, pressures up to 375 lb at the burner may be used. The latter pressure will be used in a new central station in-

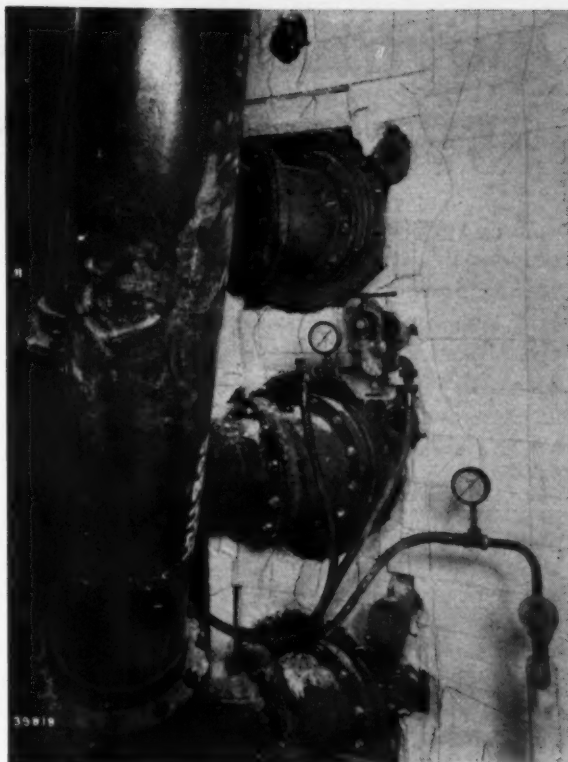


Fig. 4—Combination corner-fired burners at Schuylkill Station, Philadelphia

stallation where atomization of 8000 lb of oil per hour per burner, equivalent to about 120,000 lb of steam per hour, is specified. This, it is believed, will be the world's record per burner. Generating 210,000 lb steam per hour with two oil burners in the same furnace, using pulverized coal units, was recently accomplished.

The most recent application of oil firing to furnaces designed primarily for pulverized coal has been in the corner-fired type. In this furnace, the pulverized coal burners have flat nozzles and are located, two or three in a vertical row, in each of the four corners of the water-walled furnace and direct their flames tangentially to an imaginary circle about eight feet in diameter in the center of the furnace. Fig. 4 shows such an arrangement in the new high-pressure units at the Schuylkill Station of the Philadelphia Electric Company. There is no refractory around the burners and the furnace bottom is normally covered with molten slag. There is no room for diffuser cones or rotation blades to whirl the air and induce turbulence. The atomizer is introduced through the ignition tube and discharges its oil spray in the path of the incoming air. The mixing of the oil spray with the secondary air is necessarily a "catch-as-catch-can" affair. It is also necessary to design the atomizer to throw a spray that will not impinge on the side walls. To burn oil under these conditions successfully was said by many authorities to be impossible, but inasmuch as the impossibilities of yesterday are the commonplaces of today, it was tried out and the results have proved extremely satisfactory.

For all the reasons given and others not stated, the combination of oil and pulverized coal firing in the same furnaces and using a common method of supplying air for combustion has been growing in favor and has become generally recognized as the best engineering practice.

Operating Experiences with Large Turbine-Generators

This review of practice and operating experience with 179 German turbine installations, of a unit capacity of 10,000 kw and over, is based on the report for 1937 of the "Wirtschaftsgruppe Elektrizitätsversorgung" (Electric-Generating Group) and is translated from the June 25, 1938 issue of *Die Wärme*. It shows the trend in German turbine types from 1925 to 1937, discusses readiness to serve, use factor and outages with the several types.

THESE installations, all of which were put in service since 1925, represent a total capacity of nearly four million kilowatts and delivered during 1937 over 14 billion kilowatt-hours, or 62 per cent of the total electrical energy produced in German public utility plants. Of the 179 turbines covered only 15 are of the back-pressure type, the remainder being condensing.

Fig. 1 represents trends in German turbine types during this 12-year period. It will be noted that the present preference is for the single-cylinder machine in contrast with the multiple-cylinder type which prevailed up to about 1929 or 1930. Furthermore, the double-generator Ljungström type is now becoming popular and the single-rotation radial-flow type is also coming into use.

There has been little change in the capacity, pressure and steam temperature of individual units during the past few years. About 60 per cent of the total capacity

is represented by units between 10,000 and 20,000 kw; about 37 per cent by units between 20,000 and 40,000 kw; and only 3 per cent by units of more than 40,000 kw. Low pressures still prevail with 64 per cent of the units operating below 355 lb per sq in.; 31 per cent between 355 and 570 lb; and only 5 per cent over 570 lb. Steam temperatures are comparable, with 23 per cent operating

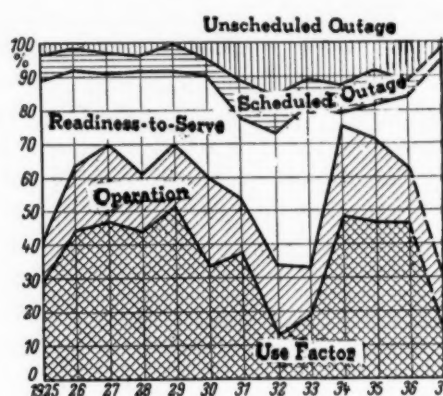


Fig. 2—Operating factors

below 707 F; 53 per cent between 707 and 797 F; and 24 per cent above 797 F.

The operating factors are represented diagrammatically in Fig. 2 which shows the readiness-to-serve, the operating time, scheduled outage, unplanned outage and use factor. The ordinates represent percentage of the total hours in the year and the abscissae the particular years. The small use factor and large unscheduled outages of turbines which went into operation during 1932 and 1933 are noticeable. During these years fewer machines went into service, because of the business situation in Germany, and the behavior of a few units may have greatly influenced the findings. The time consumed by unscheduled outages of the newer turbines is more than double that indicated for the older machines placed in operation from 1925 to 1930, from which the report concludes that the older machines, because of their heavier construction, were less liable to forced outage. It is also suggested, as a further explanation, that troubles are more likely to occur during the first year or two of operation and are corrected. After the tenth year of service the readiness-to-serve shows a tendency to drop.

Commentating further, the report states that the Ljungström turbines have shown especially long unscheduled outages. The best showing is made by the single-shaft two-cylinder machines running at 1500 rpm. These had a use factor of about 53 per cent.

With all types the major troubles have been in the turbine end of the unit, with generator, condenser and auxiliary troubles ranging in the order named. During 1937 these were of the order of 72, 21 and 7. About half the turbine troubles were attributable to blading, this being particularly true of the high-pressure units and those of the Ljungström type.

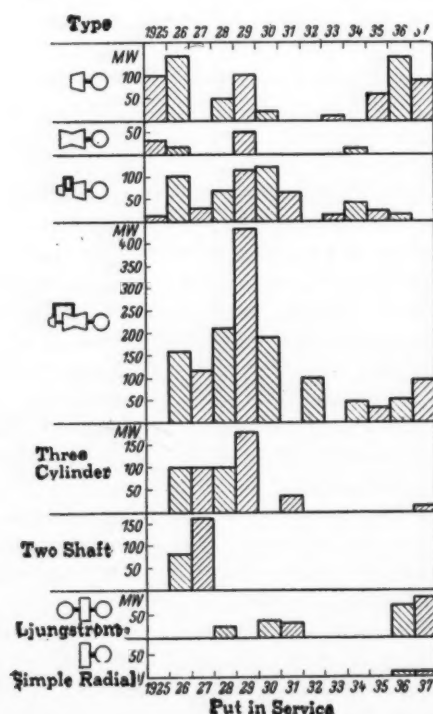


Fig. 1—Total capacity of types and year built

Chromates for Corrosion Prevention in Standby Boilers

By RICHARD C. ULMER and J. MURRAY DECKER

Research Department, The Detroit Edison Company

Various procedures have been advocated for the prevention of corrosion in standby or idle boilers. In general, the selection of any given treatment is dependent upon the length of time the boiler is to be idle and also upon whether it is to be put into service occasionally on short notice. This article reviews the various procedures now in use at different plants and discusses in detail the employment of chromates in standby boilers at the Conners Creek Plant of The Detroit Edison Company.

If a boiler is to remain idle for a long period and is not to be steamed, the best procedure seems to be to drain it, thoroughly dry the surfaces and to maintain this condition. The boiler may be sealed and trays of quicklime or other desiccants used if necessary (1).¹ Good results have also been reported in Germany with the use of ammonia gas for the prevention of corrosion in standby boilers (2).

On the other hand, if the unit is to be steamed occasionally on short notice, it is best to leave it filled with water and take steps to prevent corrosion. For this purpose numerous remedies have been suggested. In any case, it is desirable that the treatment be such that the boiler may be steamed without first draining or altering the solution in any way. The methods applicable to this purpose may be divided into three groups:

1—PREVENTION OF OXYGEN OR OTHER CORROSIVES FROM ENTERING THE BOILER. Good results have been obtained by filling boilers with deaerated alkaline water and keeping out all air and other corrosives during the standby period (2). Such a procedure is unreliable, however, because it is very difficult to take a boiler out of service or to fill it without having considerable oxygen present, and it is still more difficult to prevent oxygen from entering the boiler during the standby period.

2—MAINTENANCE OF AN EXCESS OF AN OXYGEN ABSORBENT IN THE BOILER WATER AT ALL TIMES. Various substances, such as sodium sulphite, ferrous compounds and tannins, have been used for this purpose and in many cases have given excellent results (3). It is difficult, however, to maintain uniform concentrations of such compounds in all parts of the boiler owing to reaction with oxygen either while filling or during the standby period. Corrosion will then occur at points where the oxygen absorbent concentration has been reduced.

¹ Numbers in parentheses refer to appended bibliography.

3—PREVENTION OF THE EFFECTS OF OXYGEN. This type of treatment may be further divided as follows:

(a) USE OF PAINTS OR PROTECTIVE COATINGS. Good results have been reported from the use of paint (4), such as Apexior, providing it is correctly applied to a clean surface. It is, however, very difficult to obtain a completely clean surface in boilers which have been in operation for some time; therefore such protective coatings are of limited value. Such coatings if porous or discontinuous actually aggravate the condition by causing the attack to be concentrated at the exposed places.

(b) FORMATION OF AN INSOLUBLE IRON SALT AT THE ANODIC OR CORRODIBLE PARTS. The compounds most often used for this purpose are sodium hydroxide or carbonate, sodium silicate and, more recently, sodium arsenite (3). The alkaline salts, in the presence or absence of oxygen, reduce the solubility of ferrous hydroxide, and thus enable the metal to become passive, that is, protected by an oxide film. This treatment is entirely protective providing that a continuous film is formed in contact with the underlying metal, but in many cases small blisters form over the corroded regions and, as a result, concentration cells may be established due to the change in hydroxide ion concentration in the solution under the blister. Again, the blister may act as a screen, preventing oxygen from coming in contact with the metal under it, and the concentration cell effect may, therefore, be increased and corrosion may occur at these points at a greater rate than in the absence of alkali. Sodium silicate is undesirable owing to the danger of formation of scale (3), and little is known about the use of sodium arsenite.

(c) USE OF AN IMPOSED ELECTROMOTIVE FORCE. Since corrosion of iron occurs only at anodic areas, it may be prevented by making the parts to be protected the cathode in a galvanic cell. This may be accomplished by placing electrodes in the water in various parts of the boiler and by use of direct current imposing an emf between the boiler and the electrodes, making the boiler parts the cathode and the installed electrodes the anode (5). This method would be quite effective provided that all parts of the boiler could be reached, but it is usually impracticable to install electrodes so that all drums and tubes are protected.

(d) USE OF OXIDIZING AGENTS SUCH AS CHROMATES. These compounds tend to form a continuous protective oxide film over the entire surface of the boiler and thus to prevent corrosion.

Experiences at Conners Creek Plant

In 1935-1936, owing to the replacement of old boilers at the Conners Creek Power Plant with new ones of higher capacity, it became desirable to lay up some of

the remaining old boilers. Owing to load conditions it was thought advisable to lay up these boilers in such a manner that they could be used intermittently and on short notice. For this reason it was decided to lay them up filled to the operating level with treated water.

The first treatment employed was one involving the use of sodium hydroxide and sodium sulphite. Sufficient chemicals were added to the water to give a final concentration of 50 ppm of hydroxide ion (OH^-) and 100 ppm of sodium sulphite (Na_2SO_3). This method was abandoned, however, after it was found that it was difficult to obtain the same concentration or even to maintain an excess of sodium sulphite at all points and that considerable corrosion in the form of pitting occurred throughout the boiler due to this difference of concentration. The use of sodium sulphite would probably have given good results if steps had been taken to circulate and mix the sulphite and to test the concentration at frequent intervals during the standby or idle period. Such a procedure, however, would have been rather costly and it was thought best to use a chemical which was not adversely affected by air. It was therefore decided to treat one of the boilers with sodium hydroxide and sodium chromate. The boiler was first thoroughly cleaned by wire-brushing the drums and turbinizing the tubes. Sufficient sodium hydroxide and sodium bichromate to give a concentration of 30 to 50 ppm of hydroxide ion (OH^-) and 100 to 200 ppm of sodium chromate (Na_2CrO_4) was then placed in the water storage tanks, and after thorough mixing, the solution was pumped into the boiler to the operating level. The boiler was then closed tightly and laid up in this manner for one year. Monthly samples obtained from various points in the boiler showed that the concentration did not diminish and remained the same in all parts. No additional chromate or hydroxide was added during the year's time.

At the end of the one-year standby period, the boiler was drained and opened for inspection. The metal was found to be covered with a very thin, even coating of oxide. No objectionable corrosion was observed below the water line. A small amount of general corrosion had occurred in the drums above the water line but this was not considered serious.

The other standby boilers at the Connors Creek Plant were then drained, cleaned and filled to the operating level with water containing 30 to 50 ppm of OH^- and 100 to 200 ppm of Na_2CrO_4 . In cases where a boiler was already filled with water, the necessary chemicals in concentrated solutions were added to the top drums and the water and chemicals thoroughly mixed by circulating the solution from the lower to the top drums by means of a pump. Special care was taken to insure uniform initial concentrations of OH^- and Na_2CrO_4 in all parts. These boilers were also found to be in satisfactory condition one year after being treated.

In one case it was found necessary to steam a boiler which had been treated with chromate. After it was again shut down, samples of boiler water were tested for chromate. No trace of chromate was found in the boiler water, and inspection showed that during operation, which was at 220 lb pressure, the chromate had been reduced to oxide and had been deposited on the tubes and drums. This caused no difficulty other than the loss of the chromate, and the boiler water was again treated with sodium hydroxide and sodium bichromate,

the chemicals being added to the top drums and the solution circulated by means of a pump as before. This boiler was also found to be in good condition one year after being treated.

Discussion of Theory of Chromate Treatment

From the standpoint of the now universally accepted electrochemical explanation of the mechanism of chemical reactions, all reactions may be divided into two parts which may be called anodic and cathodic, according to whether the electrodes absorb or give up electrons. In the case of the corrosion of iron by neutral or alkaline solutions, the anodic part of the reaction is the solution of the iron in which the iron gives up electrons; whereas the cathodic part is the liberation of hydrogen in which the hydrogen takes up electrons. The iron that dissolves at the anodic areas is precipitated as ferrous hydroxide by sodium hydroxide from the solution or from the cathodic reaction. The two parts of the reaction may take place at one point, the hydrogen appearing where the iron is dissolved, in which case the reaction is a simple chemical or electrochemical one. But in highly conducting solutions in contact with metal plates of appreciable thickness, the two parts may take place at different points, especially if a non-uniform or partially adherent film exists on the surface of the metal.

Although the reactions at the anode and those at the cathode must occur at the same rate, it often happens that the corrosion rate is governed almost entirely by the rate of the reactions occurring at only one of these points. In this respect the character of the corrosion products is very important. When the reactions of corrosion supply a product that is insoluble and which can form an impermeable solid film in contact with the metal, solution of the metal soon ceases and no further corrosion occurs. If, as mentioned earlier, the film is non-uniform or discontinuous or is formed out of contact with the metal in such a way as to screen the metal, the action of the film is often deleterious in that it causes speeding up of corrosion in certain areas owing to electrolytic concentration-cell action. The part under the partially permeable film usually becomes anodic and pitting or local corrosion commences there; whereas that part which is exposed is cathodic and does not corrode. The corrosion produces more of the same type of film which strengthens the electrolytic cell and thus causes the pitting action to be self-sustaining.

From this discussion it is evident that one of the most direct ways to prevent corrosion in standby boilers is to cause the formation of a continuous impermeable film in close contact with the metal. In the case of iron in waters containing sodium hydroxide, a film of ferrous hydroxide is formed almost instantaneously, but usually there are places where the film is not in contact with the metal or where the film is porous. Corrosion is then actually concentrated at these points. It is in this respect that chromates become of advantage due to their film-repairing properties.

The invisible film on iron immersed in an alkaline chromate solution has been isolated by Evans (6) and analyzed by Hoar (7) who finds that only small amounts of chromium are present. Apparently the film is largely invisible ferrous oxide similar to that which forms almost instantly on iron exposed to other alkaline salt solutions. It is reinforced at its weak points with small amounts of an iron-oxide and chromium-oxide mixture which may

be the same oxide combination that forms the protective coating on stainless steel. Thus, whereas in the absence of chromates, iron is corroded at weak places in the oxide film, the same iron does not corrode in solutions containing chromates. The continuous presence of chromates is necessary to repair any fresh weakness which may arise in the film.

It has been shown that chlorides, if present in appreciable amounts, will cause the film formed by the chromates to be porous and only partially protective unless high concentrations of chromates are present. If water containing an appreciable amount of chlorides is used, the chromate concentration therefore should be increased over the concentration that would be used in ordinary waters (6).

For a more complete discussion of the use of chromates and other oxidizing agents for the prevention of corrosion, the reader is referred to the work of U. R. Evans (6).

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Accidents among Utilities

The National Safety Council has just issued a report on accident rates among public utilities for the year 1937. With 650 utilities reporting, they ranked fourteenth in frequency and twentieth in severity in a list of thirty major industries. Frequency is defined as the number of disabling injuries per million man-hours and severity as the number of days lost per thousand man-hours worked. In comparison with 1936 the frequency in the utility field increased 1 per cent but the severity decreased 4 per cent. Since 1926 the decrease in frequency

has been 75 per cent and the decline in severity 64 per cent. This surpasses the average for all other major industries which during this period decreased 61 per cent in frequency and 42 per cent in severity. Despite this favorable comparison fatalities were higher in the utility field. It is significant that the large utilities had lower injury rates than small or medium size companies.

Electrical apparatus was the principal agency involved in injuries, being responsible for over 50 per cent of the serious accidents, whereas mechanical causes accounted for about 30 per cent. Unsafe methods of performing work, improper guarding and defective equipment were responsible for one-seventh of the latter. However, the principal cause of all serious accidents was traceable to improper attitude on the part of employees, such as disregarding instructions, recklessness and abstraction.

Again, the Nebraska Power Company had the distinction of having the lowest accident frequency rate among large companies for 1937. It also had the largest reduction in frequency from 1935 to 1937 and the greatest decrease in severity. This company, it may be recalled, had the lowest record from 1931 to 1934.

A Unique Boiler Installation

In contrast with the large modern steam generating units, which have received so much attention in the technical press, is this boiler that serves a sawmill in the wilds of Idaho. As can be seen from the photographs, the setting is of fieldstone and cement and the weight of the boiler is carried on concrete posts upon which the lugs rest. The steam line from the dome to the engine is encased and insulated in a wooden box and a safety valve of the weight-and-lever type is employed.

The feed pump is hand operated. On the far side of the pump a hose (not shown) leads to the boiler and the hose in the foreground takes water from a small stream. The stack extends about twenty feet above the setting.

Our correspondent did not state the steam pressure, nor are performance figures available. One can only guess at the probable effectiveness of the insulation provided by this unique setting.



A hand-operated feed pump and fieldstone setting feature this boiler installation

The Central Station in One Man's Lifetime

By GEO. A. ORROK

Consulting Engineer, New York, N. Y.

An abstract of a paper presented at the International Engineering Congress, Glasgow, June 22, 1938. Beginning with the Pearl Street Station in 1881 the author traces the improvement in performance through the intervening years to the present era of high pressures and high steam temperatures. An interesting discussion of the "topping" plant is incorporated.

IT WAS a little more than a hundred years after Watt's epoch-making inventions that the first central station for the generation of power in bulk and for the distribution of power and light to many customers was built and used. Hence it is that the entire development of the central station has taken place within the author's lifetime, and with this development he has been closely associated.

The electric generator and motor were quite rudimentary at that time. Dynamos having less than 50 per cent efficiency were common, being used for arc lighting. But about 1879, Edison conceived the idea of an electric generator with a low internal resistance coupled with an incandescent lamp of high internal resistance, and the two experiments came to a satisfactory conclusion within a day or two of each other in the latter part of 1879. It was at this time that the idea of the central station with its generator, its distribution system, its incandescent lamps and all the small paraphernalia of fuses, switches, insulators, etc., was evolved in Edison's mind, and the central station may be said to have been born. His first bipolar machine had an efficiency of about 90 per cent and his later machines were even better; the jumbo dynamos testing at something over 90 per cent.

Construction of the Pearl Street Station was begun in 1881 to serve the Wall Street district in New York. In the choice of his apparatus for this station, Edison was particularly happy. He picked out the water-tube boiler, then little known. His jumbo dynamos were direct-connected to Porter-Allen high-speed engines. He provided a fan to cool the generator windings, and used prototypes of most of the modern machinery which goes into the makeup of a central station. This central station was put in service on September 4, 1882. Dr. J. W. Lieb, electrician of the station and the designer of the circuit-breakers, threw the switch and put the system to work.

Central stations in other cities followed. Two of the earlier jumbo dynamos came to London to be installed at the Holborn Viaduct by one of Edison's assistants, Johnson. Dr. Lieb was sent to Italy in November 1882, and soon had the Milan Edison central station at work. Colonel Crompton started the development of his first station at Kensington Court after his successful work at the Imperial Theatre in Vienna in 1883-1886.

Very few records were made of the operating costs in those early days. At the Pearl Street Station the best figure that can be obtained is about 10 lb of coal per kilowatt-hour generated. Colonel Crompton's reports for the Kensington Station show practically the same economy, which was bettered, of course, after more was learned about handling the machinery. The Adams Street Station in Chicago, which was started shortly after the Kensington Station, ran on about the same amount of coal. The thermal economy of these early stations may thus be put at around 120,000 to 140,000 Btu per kwhr, which was regarded as good practice at that time and, considering the simplicity of the station design, they made enviable records.

Boiler Efficiencies

It was just about the time of the starting of Pearl Street that W. C. Unwin tested a set of Lancashire boilers in England and reported an overall efficiency somewhat in excess of 80 per cent, based on the high heat value of the coal. About the same time, J. H. Hoadley, in America, tested the boilers at the Pacific Mills, a return-tubular installation, and reported boiler efficiencies of the same order.

Since that time there have been added superheaters which were invented early but disused about 1860-1865; economizers, also an early invention, air heaters, the stoker, pulverized coal firing, the extension of forced- and induced-draft apparatus, which had been more prevalent in England than in America and, finally, systems for automatically regulating the fuel-air ratio and so securing the highest possible efficiency. Modern boilers frequently show operation of nine months without shutdown and an overall economy day in and day out over a year of the order of 86 to 90 per cent on the high heat value of the fuel, no account being taken of the power to drive the stoker or forced- and induced-draft fans.

The Prime Mover

It will be noted that both Edison and Crompton employed high-speed engines for their prime movers. As larger powers were required the piston speeds were increased, but the revolutions per minute decreased. By

1900, engines with low-pressure cylinders as large as 96 in., of 5-ft stroke and running at 75 rpm became standard. These engines were built in the two- and three-cylinder compound, triple and quadruple arrangements and developed up to 12,000-14,000 hp, or 8000 kw.

Shortly after 1900 the steam turbine developments of Parsons, DeLaval, Rateau and Curtis began to be used, and soon superseded the reciprocating machinery. Turbine efficiency at first was not as good as engine efficiency, but with size and refinements of design the improvement was marked. The adaptability to superheat and better vacua have helped in the development of a nearly perfect prime mover.

Station Efficiency

But, when all is said, it is not boiler efficiency or turbine efficiency that is the criterion of the excellence of a central station, but the overall efficiency, the product of the separate efficiencies of all the pieces of apparatus from the receiving hoppers for the fuel to the meters on the feeders where they leave the station.

Today it is not a case of 10 lb of coal per kilowatt-hour or 120,000 to 140,000 Btu per kwhr. Statistics of the central stations in the United States are quoted in Table I, figures for the earlier years being added from the author's files. These figures are for the whole industry (more than 95 per cent of the output).

TABLE I—ECONOMY AND EFFICIENCY OF THE CENTRAL STATION INDUSTRY IN THE UNITED STATES¹

Based on coal of 13,800 Btu			
Year	Lb Coal Per Kwhr	Btu Per Kwhr	Thermal Efficiency Per Cent
1882	10.00	138,000	2.48
1890	8.50	117,000	2.92
1895	7.00	96,500	3.54
1902	6.70	92,500	3.70
1907	5.40	74,500	4.59
1912	4.40	60,600	5.64
1917	3.30	45,500	7.51
1920	3.00	41,400	8.25
1925	2.10	29,000	11.79
1926	1.95	26,900	12.70
1927	1.84	25,400	13.45
1928	1.76	24,300	14.05
1929	1.69	23,300	14.65
1930	1.62	22,300	15.30
1931	1.55	21,400	15.95
1932	1.50	20,700	16.50
1933	1.47	20,300	16.80
1934	1.47	20,300	16.80
1935	1.46	20,150	16.95
1936	1.44	19,900	17.15
1937	1.43	19,700	17.35

¹ See *Electrical World*, January 15, 1936.

While these figures are most interesting and show what the whole industry has been doing, the improvement from 140,000 Btu per kwhr in 1882 to, say, 19,000 Btu per kwhr in 1937, does not represent the best that has been attained. These figures are averages and include stations in some cases thirty years old with low steam pres-

ures, poor vacua, low superheat, many small units and poor insulation, adding their high Btu rate to the later and better stations.

A better method of exposition would be to show the yearly records of a few of the newer and larger central stations with sufficient data to enable a reasonable appraisal of the actual progress from year to year. For this purpose twelve installations have been chosen, see Table II, commencing with what is known of Pearl Street in 1882-1883, following with Waterside No. 1, an engine station, and Waterside No. 2 with its earliest turbines. After these come two Detroit stations whose records have been made public, and Philo, a station working at 530 lb pressure, which made an exceedingly good record. Chicago follows with a station working at 575 lb pressure, and then a low-pressure gas-fired station in California. Here, owing to a combination of circumstance, the lowest cost per kilowatt-hour (fixed plus operating charges) is reached. Two pulverized-coal-fired stations working at 1300 lb pressure within a few miles of each other will be found in the next two columns. The final actual record included is that of the latest station, Port Washington, from which yearly records are available, working at 1300 lb pressure. This is a plant equipped with a single boiler and single turbine, designed for base load operation, and has the best recorded heat economy of American central stations. In the last column, through the courtesy of the American Gas & Electric Company, some estimated figures are given for the projected plant working at 2400 lb pressure and 940 F at Twin Branch.

One of the most interesting developments in American central station practice has resulted in the installation of equipment working at pressures of 1200 to 1400 lb per sq in., superimposed on older and lower pressure installations. The forerunner of these installations was the Edgar Station of the Boston Edison Company at Weymouth, Mass., soon to be followed by the Lakeside (Milwaukee) plant and a long list of later successful installations. Theodore Baumeister, Jr., now consultant on the plant at Twin Branch, designed for 2400 lb pressure, has been good enough to prepare the following discussion of the "Topping Plant," so-called, which shows the state of the art in this most important and interesting development:

The "Topping Plant"

Various reasons have justified the selection of the "topping" plant as an economic means of extending generating capacity among which the following are typical:

1. Lower cost of service.
2. Better utilization of existing electrical transmission systems.
3. Elimination of inefficient plant capacity from the system.

TABLE II—CENTRAL STATION STATISTICS, 1882-1937

Year	1882	1902	1907	1917	1925	1926	1926	1930	1933	1934	1937	1940
Name	Pearl St.	Water-side No. 1	Water-side No. 2	Conners Creek	Philo	Trenton Channel	Craw-ford Avenue	Long Beach	South Amboy	Gilbert	Port Washington	Twin Branch
Location	New York	New York	New York	Michigan	Ohio	Michigan	Chicago	California	New Jersey	New Jersey	Wisconsin	Indiana
Capacity	700	24,000	85,000	110,000	80,000	150,000	235,000	95,000	50,000	55,000	85,000	67,500
Cost per kw, \$	150.00	104.00	92.00	102.00	122.34	97.97	114.20	67.00	86.00	102.00	88	400
Output, million kwhr	8.07	31.8	43.7	47.8	83	72	80.9	714	143	313	388	75
Load factor, per cent	125	200	200	216	530	375	575	415	1,300	1,300	1,300	2,400
Steam pressure, lb per sq in.	350	385	480	578	706	707	750	750	750	750	825	940
Btu per kwhr	138,000	41,250	36,800	20,040	14,251	16,017	16,501	12,848	12,838	11,900	10,835	10,500
Fuel cost per million Btu, cents	12.7	8.0	7.6	12	11.3	14.54	18.9	5.00	13.1	17.05	15.64	15.00
Operating Costs:												
Fuel	1.75	0.330	0.280	0.240	0.197	0.232	0.311	0.065	0.208	0.204	0.170	0.153
Labor	0.75	0.115	0.090	0.057	0.038	0.070	0.049	0.075	0.053	0.024	0.027	0.027
Oil, water and supplies	0.07	0.057	0.024	0.008	0.020	0.023	0.007	0.004	0.011	..	0.004	0.004
Maintenance	0.25	0.064	0.040	0.031	0.035	0.029	0.019	0.011	0.064	0.026	0.015	0.015
Total operating costs	2.82	0.566	0.434	0.334	0.290	0.354	0.386	0.155	0.336	0.254	0.216	0.204
Fixed charges at 12.5 per cent	2.75	0.430	0.306	0.667	0.350	0.395	0.854	0.103	0.377	0.224	0.283	..

4. Reduction of the cinder and smoke nuisance by the retirement of obsolete fuel burning equipment.
5. Continued use of old equipment and plant that is still in good operable condition because of adequate maintenance in the past.
6. Better utilization of existing plant sites and structures because of higher capacities as measured by kilowatts per square foot or per cubic foot.
7. Improved fuel economy on old equipment.
8. Increased system generating capacity without attendant increases in fuel consumption.
9. Increased generating capacity without increase in the requirements for the condenser circulating water.
10. Substitution of modern large high-pressure high-temperature boilers for small low-pressure, low-temperature, less efficient equipment resulting in lower fuel, maintenance and labor costs.
11. Less burden on financing operations with avoidance of possible heavy retirements.
12. Continuance of the service life of some old equipment which is still in good physical condition but is no longer usable in its present form because of progress in the art.

This list reflects pertinent grounds for the extension of capacity by superimposing high-pressure boilers and turbines on existing low-pressure prime movers. Other alternate procedures could be employed to gain the same end of increased capacity. New full expansion capacity could be used instead of "topping." Such a program, however, would leave the old low efficiency plants still in existence or it would call for extreme retirements if complete substitution were effected. On the other hand, "topping" may serve to remedy these conditions. The removal of a multiplicity of small, inefficient, low-pressure boilers and the addition of adequate large modern high-pressure boilers, with improved efficiency, and the placing of a high-pressure turbine-generator between the new boilers and the old turbines, results in improved heat rate and labor charges for the entire plant. It is thus typical to modify a 50,000-kw plant working at 200 lb pressure, to one working at 1400 lb and of substantially double the capacity. The heat rate of the old plant might accordingly be reduced from 25,000 Btu per kw-hr to one of half that amount, or 12,000 to 13,000 Btu per kw-hr. Such a reduction in fuel rate means not only that the operating cost is proportionately lowered, but it entails the further advantage of utilizing the old fuel handling and storage system for twice the generating capacity. The same weight of coal is used to obtain a return of twice the electrical capacity that existed prior to the topping extension, and the old condensing system can be used to serve nearly twice the generating capacity.

Full Expansion vs. Topping

The alternative proposal to the topping program in the example cited would be to extend the capacity by means of a new 50,000-kw full expansion addition. In order to realize the best fuel economy on the new unit, the same conditions of initial pressure and temperature could be selected as were chosen for the superimposed plan. This new extension would be modern in all respects, and every advantage could be taken of progress in the design of low-pressure turbine and condensing plant as well as the merits of large high-pressure equipment. Such a modern full expansion extension would realize not only the thermodynamic worth of the high-pressure cycle, but it would also take advantage of the improved Rankine efficiency ratios of the latest low-pressure turbine designs. The units would be built for regenerative feedwater heating, which is generally not the case for the older low-pressure equipment that a true "topping" installation must use. There is greater latitude in the selection and arrangement of plant auxiliaries, and the auxiliary power requirements can be reduced to a minimum. The condensing plant can take advantage of the highest vacua with improved heat transfer and pump design. The maintenance and operating labor charges on the low-pressure end would be reduced at the same time as the minimum heat rate is obtained. As a consequence of this effective use of modern equipment, it is reasonable to expect that the full expansion extension will give a heat rate probably 1000 Btu better than with the "topped" plant. This would mean typically 11,500 Btu per kw-hr on the full expansion alternative as compared with 12,500 Btu per kw-hr on the "topped" plant.

The selection of the suitable program for capacity addition from between these two alternatives requires careful analysis of the economics of the problem. It is impossible to state categorically any formulation which would lead to a definite answer in all instances. Many local circumstances must be considered. The load factor on the station will be different after "topping" than it

was before on any interconnected system. The old station, because of its high production cost, would have served the peak and emergency periods. After "topping," the entire capacity of the altered plant will have become, most likely, more efficient than any other steam capacity on the system. It would therefore move from its old position near the peak to a base load rating. This shift in position is bound to influence the scheduling of all other units on the system, and particularly the present best units. Load factor in relation to system load and plant location must be studied to make certain that the most economic solution has been obtained through "topping." The price of fuel is likewise of importance.

If an extension of the same capacity were obtained by the simple addition of new full-expansion equipment, without disturbing the old plant, the economics would be different. The new capacity would rightfully take its place on the base of the load curve, while the old plant would continue to serve on the peaks. The base load would thus be carried with a minimum heat rate of 11,500 Btu per kw-hr, while the peaks would continue at the rate of 25,000. The comparison of the total cost of operation by this method with that resulting from a "topped" plant which would carry the entire load at 12,500 Btu per kw-hr is a matter heavily influenced by the load factor, fuel price and investment charges. It is reasonable to anticipate that the higher the load factor and the higher the fuel price the greater becomes the justification for "topping." Conversely, the lower load factors and fuel prices will favor the full expansion addition without alteration of the old plant.

Mercury Vapor Plant

Much has been written since Watt's time about binary vapor systems of power generation, and many combinations of vapors have been used as the medium of conversion from heat to power. Only one of these systems has been seriously successful in an operating plant, and this is the mercury vapor system developed by W. L. R. Emmet of the General Electric Company. There have been nine years of continuous operation of the 20,000-kw plant at South Meadow Station of the Hartford Electric Light Company. Started as a coal burning plant in 1928, it was changed to oil firing in 1932, and now produces about 130,000,000 kw-hr per year with an annual heat rate of 10,210 Btu per kw-hr (1936). The lowest month for which the figures have been made public is February 1937, when 10,399,600 kw-hr were generated at a heat rate of 10,130 Btu per kw-hr. Similar plants are operating at Schenectady, N. Y. and Kearny, N. J., but no figures have been made public.

The author's active interest in the central station began with the reading of the description of the Pearl Street Station in the *Scientific American* in 1882, but his first active participation came with the design and construction of the Albany Street Station of the Metropolitan Street Railway in Boston in 1891.

In the next seven years, the organization completed the design of more than forty central stations, the largest being the 30,000-kw 96th Street Station of the Metropolitan Street Railway Co., New York, consisting of eleven units. The street railway business being near saturation, the power and light business offered the best future, and in 1898 the author joined the organization led by Thomas E. Murray, Dr. J. W. Lieb and John Van Vleck. The following 31 years saw more, larger and better central stations, while the output of the industry grew from about 1,000,000,000 kw-hr in 1892 to over 90,000,000,000 kw-hr in 1929. Since then the industry has been through the depression and partial recovery, the output in 1937 being 114,000,000,000 kw-hr. But engineering progress is still going on, heat rates are being lowered and the author expects to live to see a central station delivering a kilowatt-hour on the outgoing feeders at a heat rate of under 10,000 Btu.

Grindability of Some American Coals

By H. F. YANCEY† and M. R. GEER‡

This report presents the results of grindability tests, by the ball-mill method, of 34 samples of coals from Illinois, Kentucky, Pennsylvania, Utah, Virginia, West Virginia, Washington and British Columbia. They were conducted at the Northwest Experiment Station of the U. S. Bureau of Mines, Seattle, in cooperation with the College of Mines of the University of Washington, and the results are here reviewed from Bureau of Mines Report of Investigations 3409.

THE increased use of coal as pulverized fuel has focused attention on its grindability and on the necessity of evaluating this property by a method suitable for use in the usual coal-testing laboratory. Without some knowledge of how various coals behave in the grinding operation, that is, how their use affects mill capacity and power requirements, the selection of coals for pulverized-fuel plants cannot be made on the same critical basis used in selecting coals for other types of burning equipment. The grindability of a coal serves principally as an indication of the mill capacity attainable in grinding it—not as a direct index of the total cost of grinding. Although the grindability may play a minor role at some plants, it is a decidedly important factor where pulverizer capacity limits the ability to carry high loads.

Since the grindability of coal from many beds varies in the different localities in which the bed is mined, and sometimes even in the various sizes of coal from the same mine, the reader should exercise the same judgment in using the grindability values reported as he would in using published chemical analyses.

Ball-Mill Grindability Method

The grindability indexes given in this report were made by the ball-mill method developed by the Bureau of Mines. The American Society for Testing Materials has adopted as tentative standards both the ball-mill and the Hardgrove methods. These two methods, although entirely different as to type of mill employed and testing procedure, give results that, according to the specifications for the tentative standard method, can be correlated roughly by means of the following tabulation:

Ball-Mill Grindability Index, Per Cent	Equivalent Hardgrove Grindability Index
20	29
30	43
40	56
50	68
60	80
70	90
80	100
90	110
100	118

† Supervising engineer, Northwest Experiment Station, U. S. Bureau of Mines, Seattle, Wash.
‡ Junior mining engineer, Northwest Experiment Station, U. S. Bureau of Mines, Seattle, Wash.

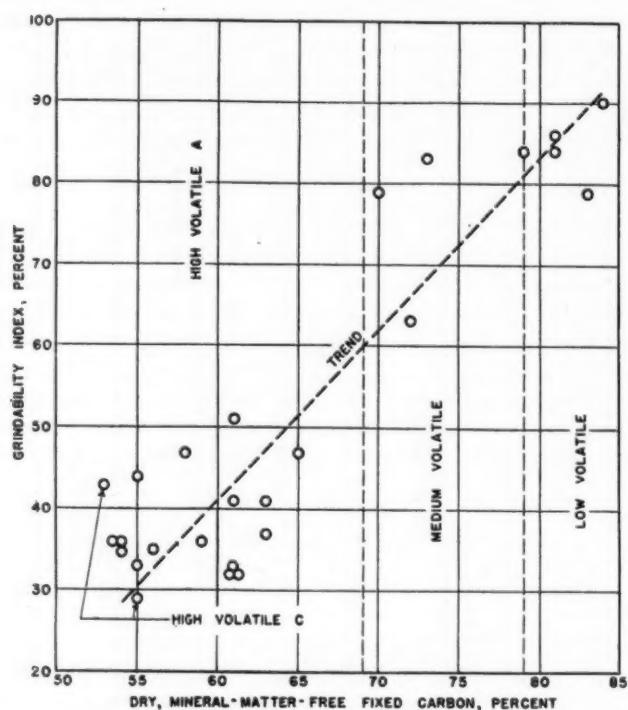
GRINDABILITY OF SAMPLES OF VARIOUS COALS

State	County	Mine	Bed	Rank and Grade	Size, Inches	Grindability Index Revolutions	Per Cent
Illinois	St. Clair	St. Louis No. 2	No. 6	(53-122) 111-A1 ¹ -S5.0	2 to 1	1163	43
Kentucky	Harlan	Low Splint	Low Splint	"	Lump	1613	31
"	"	Yancey	Harlan	(61-146) 142-A 4-F26-S1.0	"	1515	33
"	"	Crummies Creek No. 2	Darby	(61-146) 144-A 4-F22-S1.0	"	1563	32
"	"	Kellioka	Kellioka	(61-150) 143-A 6-F22-S0.7	"	1563	32
"	Pike	Majestic	Pond Creek	(66-150) 143-A 6-F28-S0.7	1 1/2 to 1	1329	37
Pennsylvania	Allegheny	Warden	Pittsburgh	(63-150) 141-A 6-F26-S1.0	1 1/2 to 1	1220	41
"	Cambria	Bethlehem No. 72	Lower Kittanning	(84-155) 142-A 8-F26-S2.0	"	556	90
"	Clearfield	Pa. Coal and Coke No. 46	"	"	Minus 3/4	561	89
"	Fayette	Banning	Pittsburgh	(65-148) 141-A 8 -S1.0	Minus 1/2	1064	47
"	"	Banning No. 2	"	(¹)	"	962	52
"	Jefferson	Adrian	Lower Freeport	(72-153) (147-A 6 -S1.0	Minus 1/2	794	63
"	Northumberland	Bear Valley	Various	(94-151) 136-A10-F26-S1.0	3/16 to 3/32	1351	37
"	Schuylkill	St. Nicholas	"	(²) 130-A10- -S0.7	"	1923	26
"	Somerset	Jerome	Upper Kittanning	(83-153) 140-A10- -S1.0	R-O-M	633	79
"	Washington	Montour No. 9	Pittsburgh	(59-144) 135-A 6- -S1.6	Plus 6	1389	36
"	"	Terminal No. 9	"	(55-147) 135-A 8-F20-S5.0	1 1/4 to 1	1136	44
Utah	Carbon	Rolapp	Castlegate	(55-142) 133-A 8- -S0.7	3 to 2	1515	33
Virginia	Lee	Bonny Blue	Pardee	"	"	1563	32
Washington	King	Elk No. 3	"A"	(54-139) 108-A20 plus-F26-S0.7	Plus 2	1389	36
"	"	"	"	(55-140) 107-A20 plus-F28-S0.7	2 to 1	1389	36
"	"	"	"	(55-140) 112-A18-F28-S0.7	Minus 1	1429	35
"	"	Bayne	Carbon	(61-143) 120-A18-F22-S1.0	3 to 2	1220	41
"	Kittitas	Roslyn No. 3	Roslyn	(56-148) 124-A16-F22-S0.7	Minus 2 1/2	1429	35
"	Lewis	Black Prince No. 2	Parkin	(52- 94) 88-A 6-F24-S0.7	3 to 1 1/4	2000	25
"	Pierce	Wilkeson	No. 7	(73-153) 135-A14-F24-S0.7	3 to 2	602	83
"	"	"	No. 4	(61-149) 138-A10-F22-S1.0	"	980	51
"	"	"	East No. 4	(70-148) 122-A18-F22-S3.0	Minus 1/16	633	79
"	Whatcom	Bellingham	Bellingham	(55-128) 111-A14-F24-S0.7	3 to 2	1724	29
West Virginia	McDowell	Lick Branch	Pocahontas No. 3	(81-154) 147-A 6- -S0.7	1 1/4 to 1 1/2	595	84
"	Mingo	Red Jacket, Jr.	Cedar Grove	(63-151) 144-A 6-F28-S0.7	1 1/4 to 1	1351	37
"	Raleigh	Cranberry No. 3	Sewell	(79-156) 152-A 4-F24-S1.0	"	595	84
"	"	Cranberry No. 1	Beckley	(81-155) 148-A 4-F28-S0.7	"	581	86
British Columbia	Vancouver Is.	Ladysmith Wellington	Alexandria	(58-144) 132-A10- -S0.7	3 to 2	1064	47

¹ High volatile bituminous.
² Anthracite.

This conversion of ball-mill to Hardgrove indexes is accurate to about ± 3 units for ball-mill grindability indexes of from 25 to 50 but are of unknown accuracy for coals outside this range.

With the ball-mill method the relative amounts of energy necessary to grind coals to the same fineness are determined by the number of revolutions of the mill required to reduce 80 per cent of the feed (500 grams of 10- by 200-mesh Tyler or No. 12 to No. 200 U. S.) fine enough to pass a 200-mesh sieve. The finished product is removed in increments of 10 per cent by stopping the mill and screening out the undersize at the end of each



Relation between grindability and rank of bituminous coals listed in the table

cycle. This procedure prevents overgrinding, maintains a more constant size distribution in the subsieve material and simulates the continuous removal practiced industrially.

Grindability Indexes

The table shows the sources of the coals tested, their rank and grade classifications, size of coal and the grindability expressed in revolutions and in per cent. The rank and grade classifications are given by the symbols prescribed by A. S. T. M. specifications. Their meaning will be illustrated by taking as an example the first Pennsylvania coal listed in the table. The two first values in parenthesis (63-150) denote rank and indicate the percentage of dry mineral-matter-free fixed carbon and the number of moist mineral-matter-free British thermal units, expressed in hundreds. These values classify this particular coal as high volatile bituminous. The symbols that follow (141-A6-F26-S1.0) denote grade and indicate that on an "as-received" basis the coal contains between 14,050 and 14,140 Btu per lb, between 4.1 and 6.0 per cent ash, has an ash-softening temperature of between 2600 and 2790 F and contains 1.0 per cent or less of sulphur.

Relation between Grindability and Rank

The data indicate a general relationship between grindability and rank, which is illustrated more clearly in the diagram, in which grindability index is plotted against percentage of dry mineral-matter-free fixed carbon for all of the bituminous coals in the table. This shows that with coals of bituminous rank, increasing fixed carbon is accompanied by increasing grindability; that is, the medium- and low-volatile bituminous coals are decidedly easier to grind than those which fall within the high-volatile class.

Unfortunately, the table does not contain enough sub-bituminous and anthracite coals to permit a comparison between the grindability of coals of these ranks. Experience indicates, however, that the maximum ease of grinding is reached in the coals of low-volatile bituminous rank and that anthracites and sub-bituminous coals are more difficult to grind.

EQUIPMENT SALES

Boiler, Stoker, Pulverized Fuel

as reported by equipment manufacturers of the Department of Commerce, Bureau of the Census

Boiler Sales

	1938		1937		1938		1937	
	No.	Sq Ft	No.	Sq Ft	No.	Sq Ft	No.	Sq Ft
Jan.....	52	201,151	52	256,368	35	42,752	65	84,889
Feb.....	48	185,257	51	198,957	45	55,173	74	89,133
Mar.....	58**	238,830**	142	791,168	50	49,039	150	211,733
Apr.....	48	195,910	60	322,669	37	52,421	75	69,937
May.....	60	330,653	113	589,347	61	68,288	83	130,782
June.....	58	190,242	76	330,524	63	86,975	77	100,585
Jan. to June Inclusive..	324	1,342,043	494	2,489,033	291	354,648	524	687,059
1937—12 mos.			861	4,058,481			941	1,178,805

** Revised

Mechanical Stoker* Sales

	1938		1937		1938		1937	
	No.	Hp	No.	Hp	No.	Hp	No.	Hp
Jan.....	28	9,484	63	25,278	76	10,991	140	21,636
Feb.....	36†	12,450†	45	16,591	76†	12,216†	120	20,650
Mar.....	54	18,820	80	38,074	52	9,434	179	24,709
Apr.....	35	12,698	72	37,185	71	11,058	154	23,064
May.....	32	10,830	65	26,327	106	15,342	137	21,443
June.....	28	9,284	49	19,787	166	21,378	186	26,627
Jan. to June Inclusive..	213	73,566	374	163,242	547	80,419	916	138,129
1937—12 mos.			659	262,834			2,628	361,346

* Capacity over 300 lb of coal per hour
† Corrected

Pulverizer Sales

	1938		1937		1938		1937	
	No.	Cap. Lb	No.	Cap. Lb	No.	Cap. Lb	No.	Cap. Lb
Jan.....	5	40,500	35	554,900	1	1,000	2	1,700
Feb.....	7	38,020	2	68,300	—	800	4	3,600
Mar.....	—	26,100	59	713,440**	1	700	1	2,000
Apr.....	2	26,600	24	257,100	—	—	—	2,100
May.....	5	33,690	22	276,800	—	—	—	—
June.....	7	49,440	15	99,150	—	—	—	—
Jan. to June Inclusive..	26	214,350	157	2,143,690**	2	2,500	1	9,840
1937—12 mos.			214	2,924,590			3	10,190

† N—New boilers E—Existing boilers.
** Revised.

Legal Relationship of Employers and Employees

By citing court decisions, the author distinguishes between the liability of employer and employee as to contracts or other dealings when the latter is a general representative or an agent having only limited authority. Liability for damages as between a plant owner and a contractor is also discussed.

THE higher courts have established rules by which one may determine when an employee is personally liable for contracts and other acts performed while in his employer's service. Also, they have clearly defined when an employer is liable for acts of his employees.

When Employer Is Liable

It is well known that employees are classified as either "general" or "special" agents. The courts have consistently held that an employer is liable for all acts of his general agents that are relevant to the employment, but is responsible for only such acts that a special agent performs as are within the actual scope of the authority given him. An employee may make a valid contract which binds his employer only under the following circumstances:

(1) When the contract is within the limit of the employee's authority. (2) Although persons dealing with an employee must inquire ordinarily as to the extent of the authority, this is not true when the employer sends the employee to perform an act with apparent broad authority. (3) When the authority to perform an act is given by an employer to an employee or representative the latter may do the work or service as he deems best. (4) If the employee is a special representative and his authority is limited, and the employer has not in some manner notified the public of the employee's broad or unusual authority, then under no circumstances may the employee make a valid contract without first submitting it to his employer for approval. (5) Any employee, no matter how limited his authority may be, can have his authority greatly increased if the employer notifies the persons, with whom the employee intends doing business, of this increase of authority.

Personal Responsibility of Employee

It is well established that an employee may be personally responsible on a contract, (1) if he knowingly makes a false written or oral statement of his authority with intent to deceive a person who intends to transact business with the employer; (2) if he performs any unlawful act with or without authority of the employer; (3) if he performs a damaging or injurious act although

By LEO T. PARKER

Attorney at Law, Cincinnati, Ohio

believing that he has authority, but actually has none; (4) if he wilfully performs an act which results in damage to any one; (5) if he does damaging acts outside his scope of authority, although while so doing he intends to render the employer a valuable service; (6) if he intentionally assumes an obligation for the employer; and (7) if he unintentionally but legally assumes an obligation while performing services for his employer.

In some instances the employee and the employer may be jointly liable; but generally speaking, the employer is relieved from liability if the employee exceeds his authority and affixes a signature or issues an order outside the scope of his employment.

Of course, it is seldom that a customer prefers to hold an employee personally responsible if he can actually hold the employer liable for the act or contract of the employee. Nevertheless, there are many records of where the employee performed an act, or made a contract that did not obligate the employer, and was held personally liable.

Under ordinary circumstances an employee is not personally liable on a contract which he makes in good faith with another who knows that he represents the employer. However, adverse situations may arise.

For example, in *Campbell v. Porter*, 61 N. Y. S. 712, the litigation involved a contract signed "John A. Porter, Agent." In this instance the court explained that where a person signs a contract, or other paper, by affixing his own name with simply the word "agent" added, such a contract is the agent's own, for which he is personally responsible.

On the other hand, in *Ballou v. Talbot*, 16 Mass. 461, it was disclosed that an employee signed a contract "Joseph Talbot, agent for Berry." In this case the court held the agent not liable, and explained the reason for the decision, saying:

"The important and effective word was not the word 'agent', not the name of the principal, but the connecting word 'for' which was apt to express the fact that the act was done in behalf of the principal, in the same manner as if the words had been transposed thus: 'For David Berry, Joseph Talbot, agent'."

Distinction between Agent and Servant

The courts have ordinarily ignored the legal difference between an agent and a servant, and have usually merely attempted to determine in a particular case whether the person was a servant or ordinary agent on the one hand, or an independent contractor, or independent agent on

the other. The controlling or principal test is whether or not the employer has the right to control the details of the work to be done by the employee. Under these circumstances the employer is liable for the acts of the employee. On the other hand, if the employee represents the employer only as to the result to be accomplished and the employer cannot directly control the employee then the latter is not an agent or a servant but an independent contractor.

Generally speaking, a servant is defined as a person employed to perform personal service for another, and who in respect to his movements or acts is subject to the other's control or right to control.

The important reason for being able to determine whether an employee is a servant or an independent contractor is that the employer is liable for all acts performed by a servant within the scope of the employment, but is not liable for any acts of an independent contractor. Moreover, an employer need not pay industrial or workmen's compensation insurance on an independent contractor. If the latter performs injurious acts he personally is responsible and the employer is relieved from liability.

For illustration, in one case a plant owner employed a person to install new equipment. He agreed to pay \$5250 upon completion of the work which, as provided in the contract, must be performed in a first-class manner. An employee of the party engaged to install the equipment was injured and sued the plant owner. The court held that the owner was not liable and explained that the independent contractor, who had employed the injured employee, was solely liable.

In another case a plant owner contracted with a truck owner to transport merchandise for a stated sum. The latter negligently killed a pedestrian whose dependents sued the plant owner. The court held the plant owner not liable because he had no right to directly control the truck owner.

On the other hand, in still another case a plant owner hired a truck owner and his truck, at \$2.50 per hr. The plant owner directed the truck owner as he would any other employee. In this case the court held the plant owner liable in damages for negligence of the truck owner who collided with another vehicle.

A plant owner may employ an independent contractor by the job, by the hour, day or week. The important point is that he is not responsible for acts of the latter if he does not direct or control him as to the method used when doing the work. The fact that the employer specifies how the job must be, when to be completed, or what job the contractor should do does not make him a legal servant.

Independent Contractor Defined

An independent contractor is one who has the right to select and employ his own workmen, the owner having no control over them, and no right to direct the manner of doing the work further than to require that it shall be done in compliance with the previous agreement. This rule is not varied by the fact that the plant owner may advance to the contractor pay for the latter's employees, or actually pays the workmen and charges this sum against the amount due the contractor.

Unfair Competition of Former Employee

The law is well settled that a court, upon suit of a former employer, will enjoin competition by former employees when such competition involves the unfair or fraudulent use of trade secrets which constitute a valuable part of the good will of the employer's business. However, this power of a court thus to prevent a person from freely carrying on a lawful business will be exercised with great caution. If, for example, the testimony shows that there were no trade secrets or data regarded by the employer as confidential; or that such secrets were unknown to the particular employee involved in the suit; or that no use was made of such secrets in soliciting business, the courts will not hold the employee liable.

Moreover, where it is shown that the former employer's customers are scattered and whose identities and addresses are generally unknown, and their addresses can be readily ascertained by a total stranger, by reference to telephone or business directories, and the former employee solicits such customers along with other prospective buyers, the courts have held that such act on the part of the employee is not unfair competition.

On the other hand, a former employer may file suit and a court will issue an injunction against continuation of unfair practices by a former employee, where it is shown that such employee had access to confidential matters relating to the former employer's business and utilized such information to his own advantage after entering into business for himself, or taking employment with a competitor.

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STEAM ENGINEERING ABROAD

As reported in the foreign technical press

Power Plant of the "Mauretania"

With the launching of the new liner *Mauretania* on July 28, *Engineering* (London) of July 29 contains an article giving certain particulars of the vessel, including reference to the power plant.

Less than half the gross tonnage of the *Queen Mary*, approximately three-fourths the length and designed for only moderate speed (about 23 knots), the *Mauretania* will obviously have much lower power requirements. Whereas the *Queen Mary* has four 50,000-hp main turbines supplied by 26 boilers operating at 440 lb and 700 F, the new ship will have only six boilers of the Yarrow small-tube, five-drum type, each rated at 68,500 lb per hr and supplying steam at 425 lb, 725 F to two main turbine sets which drive the propellers through reduction gears. Each set comprises a high-pressure, an intermediate and a low-pressure turbine driving separate pinions which engage a single large gear. Four 800-kw turbine-generators will furnish electric service to the ship.

The air heaters are of the tubular type and the closed stokehold system will be employed, with provision on two of the boilers for operating with an open stokehold when in port.

Tube Arrangement in Benson Boiler

The accompanying diagram, reproduced from a special pamphlet of Rheinmetall-Borsig Actiengesellschaft shows the hook-up of furnace tubes in the most recent design of Benson boilers. These tubes are arranged in vertical series groups connected top and bottom to common headers, adjacent groups being interconnected by outside downcomers leading from the top header of one group to the bottom header of the next adjacent group.

This construction of the bundles of furnace tubes is said to assure freedom from difficulties due to the unequal impingement of heat within the furnace, since the steam and water are mixed at the top of each bundle and delivered in a uniform mixture to the bottom of the serially connected adjacent bundle. At the exit of the radiant portion the mixture contains about 70 per cent steam and 30 per cent water. It then passes to the evaporation section, or conversion zone, located in a cooler gas region where any salts are deposited.

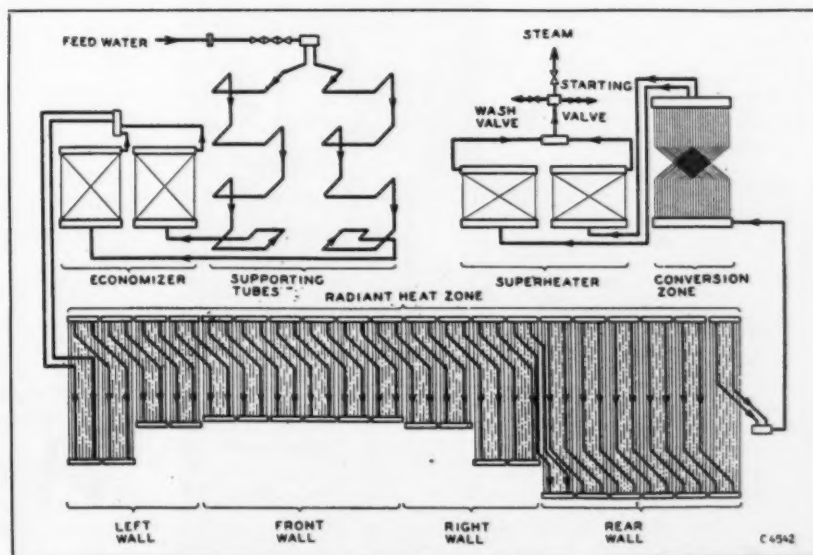
In starting, water is recirculated until the desired steam temperature is attained, whereas the reverse procedure is employed in shutting down. Where a feedwater high in salts content is em-

ployed, it is recommended that this water be wasted when shutting down as it will wash out the salt deposits in the steaming section. After 1200 to 1400 hours' operation a two-hour washing, with the pump running at slow speed, is said to remove all salts.

British Rules for Fusion-Welded Pressure Vessels

The British Corporation *Register of Shipping and Aircraft* has lately issued "Provisional Rules for Fusion-Welded Boilers and Other Pressure Vessels." These are reviewed in the August 12 issue of *Engineering* (London). For the purposes of the Rules, vessels subjected to internal pressure are classified in three grades. Class I comprises boiler drums and shells intended for a working pressure of 50 lb or more per square inch, or vessels the shell plating of which exceeds $1\frac{1}{2}$ in. thickness. Class II includes boilers and other fired vessels working at less than 50 lb per square inch, and vessels, other than those in Class I, designed to work at pressures in excess of this figure, or with the contents at a temperature of or above 300 F, or of which the shell exceeds $\frac{5}{8}$ in. thickness. Pressure vessels not included in either of the foregoing classes constitute Class III.

The thickness of shell plating, which must not be less than $\frac{3}{16}$ in., is to be determined by a formula generally similar to that already in use for riveted boilers, a coefficient *C*, appropriate to the category, taking the place of the calculated value of the riveted joint in the older equation. Details are given of the tensile, bending, nick-break and Izod impact tests required, and it may be noted



Diagrammatic layout of circuits and tube arrangement

INSIDE TIP ON INSULATION—

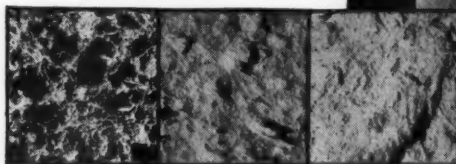
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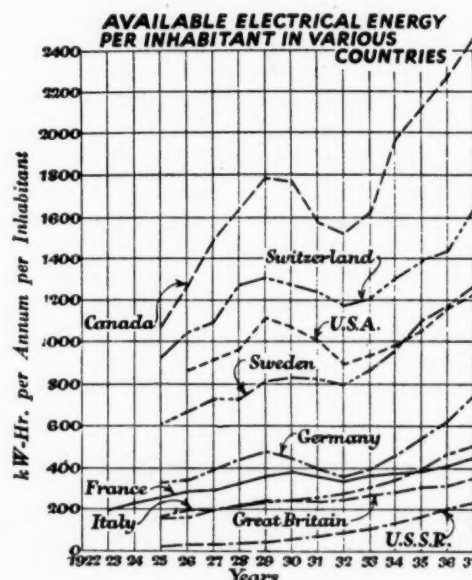
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that a satisfactory macro-section test is also specified. In the case of vessels in Class I, each one must be subjected to the full series of tests, but in the other two classes certain of the tests may be applied to sample vessels only, at the surveyor's discretion. In Classes I and II the welds are to be stress-relieved in a furnace or by other approved means. All welded pressure vessels are to withstand a hydraulic test of $1\frac{1}{2}$ times the working pressure plus 50 lb per sq in., and are to be hammer-tested at the last-mentioned pressure.

Per Capita Use of Electricity

In a paper before the recent International Engineering Congress at Glasgow, E. Mercier, the well-known French engineer, included a chart showing the annual per capita consumption of electricity for various countries,



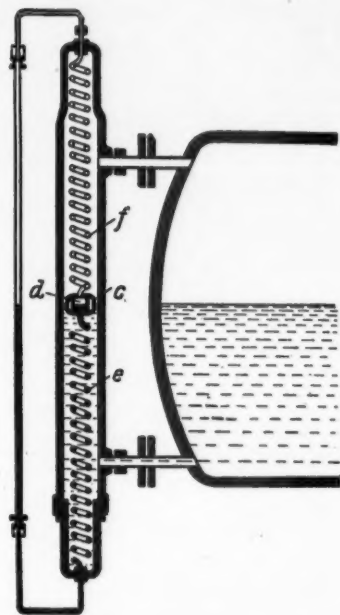
The United States is in fourth place

plotted over a period of years. This chart is here reproduced from *Engineering* of August 12. Although there is a wide variation in the use of electricity among the countries included, there is a striking similarity in the trend in each and especially marked is the coincidental effects of the depression in several countries. None of the curves seems to indicate any tendency toward the saturation point. It will be noted that the United States, since 1934, has dropped from third to fourth place.

Water-Level Indicator for High Pressure

Archiv für Warmewirtschaft und Dampfkesselwesen of April 1938 describes a rather unique water-level indicator for high steam pressures in which the gage glass is subjected to low pressure and temperature. Referring to the sketch, here reproduced, the water column con-

tains a float *c* connecting through spiral capillary steel tubes *e* and *f* with each end of the gage glass. Within the float is a small container *d* filled with a suitable fluid and sealed except for its communication with the lower tube *e*. As the float rises or falls the level of the fluid in the gage glass will always be the same as that within



The Bredtschneider level indicator

container *d*, hence will indicate the level of the water in the drum. With this arrangement danger of gage glass breakage is minimized and no stuffing boxes are required.

Operating Experiences with La Mont Boilers

The following notes on operating experiences with La Mont boilers in Germany are taken from an article by W. Arend and H. Höcker in the June 6 issue of *Archiv für Wärmewirtschaft und Dampfkesselwesen*.

According to the authors, La Mont forced-circulation boilers have been built in Germany since 1930. While only a few were built during the first few years, nearly two hundred were ordered in 1937.

In some of the earlier installations failures of the furnace wall tubes occurred due to incorrect appraisal of the heat absorption in these tubes in the extremely hot zones. A solution was sought by increasing the circulation but it developed that in most of these cases the nozzles, or orifices, were too small. Formerly, the orifice inserts (*b*, Fig. 1) were of appreciable thickness whereas now shorter orifices of somewhat larger diameter (*b*,

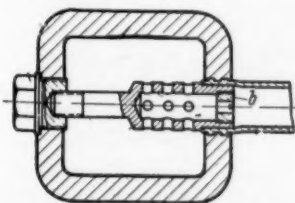


Fig. 1—Former type of nozzle insert

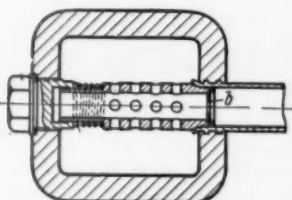


Fig. 2—Present type of nozzle insert

POSITIVE Protection

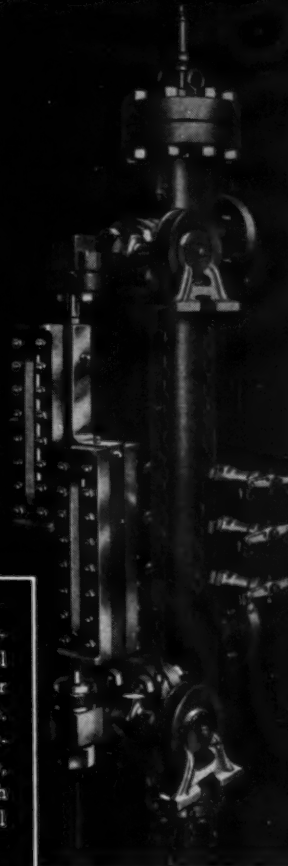


Fig. No. 4114: Yarway Forged Steel Water Column for 900 lbs. pressure. Equipped with Yarway Vertical Gage, Fig. No. 4178, with four-glass steel insert.

Hundreds of leading utilities and industrial plants insist upon Yarway Water Columns to protect their boilers.

Yarway's unique Hi-Lo Alarm mechanism utilizes balanced *solid weights* that are as indestructible and unchanging as the metal itself. Operating on the displacement principle, they literally "weigh the water level."

When the high or low water emergency occurs—instant, positive, powerful, hair-trigger action results—giving warning of danger by whistle, light, or both.

Yarway Water Columns, eight standard models, iron bodies with screwed connections for pressures up to 250 lbs., forged steel bodies with flanged connections for pressures up to 1500 lbs., are fully described in Catalog WG-1806. Write for a copy and working model.

YARNALL-WARING COMPANY

101 Mermaid Ave.

Philadelphia

YARWAY
FLOATLESS HI-LO ALARM
WATER COLUMN

Fig. 2) are employed. These are less subject to clogging and also the screens have more holes of larger diameter. Care is taken during erection to get the proper sized orifices into the various tubes.

Nozzles Necessary at Tube Entrance

Experiments have shown that nozzles are necessary at the tube entrances; that in their absence circulation may be increased thirty to forty times the steam output without avoiding unequal distribution and pulsations alternating in steam and water discharges from the tube. It is believed that with the proper nozzles circulation may be reduced from eight to five times the steam output at 425 lb pressure and less for higher pressures.

With regard to the circulating pump, the size of its suction must be ample, otherwise a sudden pressure drop in the boiler may cause a break in the suction water by its flashing into steam. By limiting the suction pressure drop and locating the circulating pump at a low level so that a high static suction pressure prevails, such interruptions may be avoided. If considerable fluctuations in boiler pressure occur one may introduce cold feedwater into the pump suction, but this must be regulated in order to avoid overfeeding the boiler.

Formerly, the power consumption of the circulating pump was held against this type of boiler. Recent measurements, however, have shown this to be about 15 per cent of all the auxiliary power and to be equivalent to only 0.6 per cent of the boiler output at full load.

Proper Feedwater Essential Despite High Velocities

Originally it was believed that, because of the high water velocities in the tubes of a La Mont boiler, there would be no scale deposits, hence little need for feedwater treatment. However, experience extending over eight years has shown this assumption to have been unwarranted. The conclusion of the authors is that this type of boiler is just as sensitive to feedwater conditions as natural circulation boilers.

To avoid plugging within the banks of tubes, the following measures have been found justifiable.

1. The screen basket in the drum over the pump suction must not be a sludge catcher but serve only to catch larger foreign matter.

2. To keep sludge away from the distribution header, screens with smaller holes have lately been installed within the discharge line of the circulating pump. An alarm is installed to warn when plugging occurs. While the screen is being cleaned the duplicate pump is operated.

3. Should the screens ahead of the tube orifices become plugged they may be cleared by reversing the flow. This is effected by closing the circulating pump valve and opening the blowoff valve on the distribution header. During this period the rate of firing is diminished.

In the La Mont boiler it is impossible to bore out scale with tube cleaners as in ordinary boilers. Instead, a dilute solution of muriatic acid with a protective colloid is circulated to clean the tubes. A three per cent solution of muriatic acid, without a protective colloid, will remove the scale but will attack the cast-iron impeller of the circulating pump.

The weight of water in a La Mont boiler is only about 50 to 60 per cent of that in the average natural circulation boiler.

Fuels Meeting at Chicago

The second Joint Meeting of the Coal Division of the A.I.M.E. and the Fuels Division of the A.S.M.E. will be held at the Palmer House, Chicago, October 13 to 15, under the sponsorship of the Western Society of Engineers with other local engineering groups cooperating. The following program has been announced:

Thursday, October 13

Registration, 9 a.m.

JOINT MORNING SESSION

Chairman—W. S. Monroe

"The Bureau of Mines Experimental Coal Hydrogenation Plant" by Dr. A. C. Fieldner and Dr. H. H. Storch, U. S. Bureau of Mines

"Influence of Mechanization on Location of Coal Production in Illinois" by Paul Weir, Consulting Engineer, Chicago

Buffet Luncheon, 12:30 p.m.

JOINT AFTERNOON SESSION

Chairman—Alex Bailey

"Fundamentals of Combustion in Small Underfeed Stokers" by Dr. C. A. Barnes, Battelle Memorial Institute

"Iowa Coal as a Domestic Stoker Fuel" by Prof. M. P. Cleghorn, Iowa State College

"Factory Testing of Propeller Mine Fans" by Raymond Mancha, Jeffrey Manufacturing Co.

EVENING SESSION

Buffet Dinner, 6:30 p.m. at the Palmer House.

Friday, October 14

JOINT MORNING SESSION, 9:30 a.m.

Chairman—Tom Marsh

"Use of Low-Grade Coals in Modern Steam Generating Equipment" by Ollison Craig, Riley Stoker Corp.

Panel Discussion on Coal Purchasing

Viewpoint of Preparation of Coal, by J. B. Morrow

Viewpoint of Purchasing Agent, by T. W. Harris, Jr.

Viewpoint of Coal Sales, by B. Gebhardt, Chicago

Viewpoint of Purchasing for a Municipality, by T. Jeffords

Viewpoint of the Consumer—Speaker to be announced later

"The Effect of Preparation on Ash Fusibility of Certain Illinois Coals" by Dr. L. C. McCabe and Dr. O. W. Rees of the Illinois State Geological Survey

AFTERNOON SESSION, 2 p.m.

Chairman—Newell G. Alford

"Mechanical Mining at Consolidated Coal Company" by G. Stuart Jenkins

"Material Handling in Coal Preparation Plants" by Nelson L. Davis

"Haulage in Strip Coal Pits" by Albert L. Toenges

AFTERNOON CONCURRENT SESSION ON SAFETY, A.I.M.E.

Chairman—Gordon MacVean

"The Safety Practices of the Koppers Coal Company" by L. C. Campbell

"Recent Trends in Rock Dust Practice" by H. P. Greenwald

"Organized Safety in the Anthracite Field" by Clyde G. Brehm

AFTERNOON CONCURRENT SESSION, W.S.E. and A.S.M.E.

Chairman—Lawrence Gayton

"Use of Metals for High-Pressure High-Temperature Steam Generators" by B. W. Whitmer

"Coal for Metallurgical Furnace Firing" by W. R. Bean

"Ash Handling" by J. J. Peterson

EVENING SESSION, 8:30 p.m.

Banquet, 8:30 p.m., Palmer House

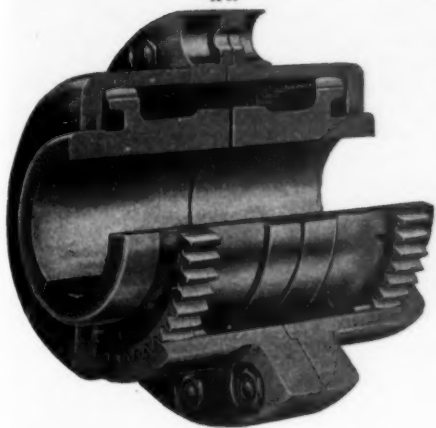
Toastmaster, Dr. W. L. Abbott

Speaker, Howard Eavenson, President, American Institute of Mining and Metallurgical Engineers, 1934.

Saturday, October 15

Inspection trips to Northern Illinois Coal Corporation's strip mine at Wilmington, Ill., the Inland Steel Company at Inland Harbor, Ind., the Goodman Manufacturing Company and the Fisk Street Station of the Commonwealth Edison Company.

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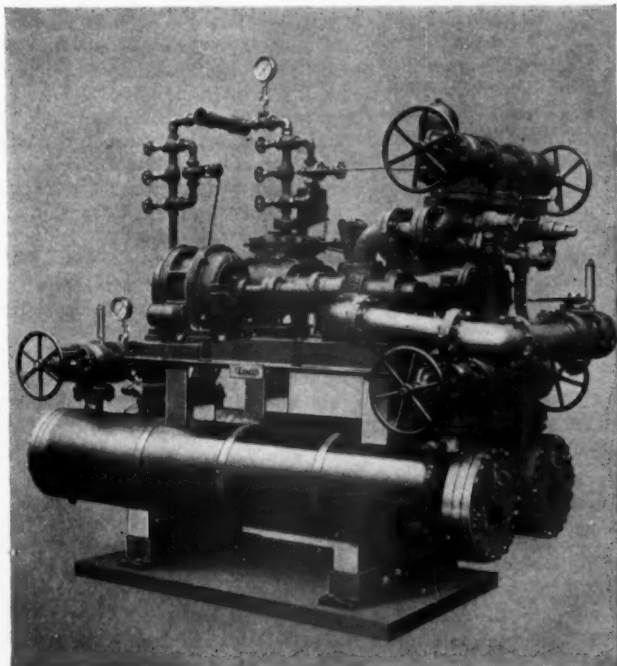
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A steam-electric system for high duty service.
Capacity 400,000 pounds of steam per hour.

The heart of every oil burning plant is the oil pumping and heating equipment—it must not fail.

ENCO systems are designed above all for dependability. Relief valves and automatic controls for pressure and temperature are used so that the oil is delivered to the burners with safety and at the proper temperature and pressure for efficient burning.

Duplicate pumps and heaters are used, each of full capacity. These are interconnected so that operation is obtained with any combination of pumps and heaters.

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The finished product is a complete machine, ready to place on foundation and to receive the pipe connections.

Write for Instruction Bulletin OBI-38 for the care and operation of Oil Burner Installations and Bulletin OB-37 describing ENCO OIL BURNING EQUIPMENT.

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17 Battery Place, New York, N. Y.**

NEW CATALOGS AND BULLETINS

Any of these publications will be sent on request

Belt Conveyors

A 24-page bulletin covering details of a new line of roller-bearing equipped belt idlers has lately been issued by the C. O. Bartlett & Snow Company. The idlers described are so constructed that the exact adjustment of the bearings can be made at the factory and the rolls mounted in the brackets in the field without altering the adjustment.

Coal Handling

Bulletin No. 138 issued by the Gifford Wood Company deals with material handling and conveying machinery as applied to a wide field of industries and devotes considerable space to coal handling and storage both inside and external to the power plant. The various components of such systems are described and illustrated and the company's five-point plan of service is featured.

Combustion Control

A 32-page bulletin has just been issued by Bailey Meter Company dealing with the application of the Bailey "steam flow—air flow" automatic readjustment type of air-operated combustion control. In addition to describing and illustrating the various elements of the control system, the bulletin explains fundamental principles involved in controls, both for boilers fired with stokers and those fired with fuels in suspension. Several actual installations are shown diagrammatically and illustrated with installation photos.

D-C Motors

Fairbanks-Morse direct-current motors, are described in Bulletin 2260. These are supplied in sizes up to 200 hp with a variety of mechanical modifications for both high-and-low voltage operation. Motors in ratings up to and including 7½ hp at 1750 rpm are built with NEMA frame (284 frame and smaller) and mounting dimensions. The open-construction, ball-bearing motors in ratings of 10 hp at 1750 rpm and larger have frames especially adapted to the larger machines. Construction details are described and illustrated.

Dust Collection

A new booklet on Industrial Dust Collection has just been completed by Buelle Engineering Company. This system employs the Van Tongeren principle of employing the energy of the double eddy currents to perform useful work. The principle is explained, various applications are discussed and the testing laboratory facilities of the company are shown.

Fans

Mechanical draft fans, of the type generally used for forced and induced draft in steam power plants, are covered in a new 36-page catalog issued by the Green Fuel Economizer Co. These include backward- and forward-curved fans, straight-blade fans and multi-blade fans, the characteristics of each type being explained in detail and illustrated by characteristic curves. The three common systems of volume control, namely, by dampers, inlet vanes or variable fan speed, are explained, and illustrated. A wide variety of fan arrangements are shown and balancing and testing facilities are illustrated. Engineering data are included.

Insulation

Quigley Company, Inc., has issued an 8-page illustrated bulletin on Insulag, a non-shrinking refractory lagging for interface temperatures up to 2200 F, or directly exposed to 2000 F, which can be applied on hot surfaces. One inch of Insulag is stated as equivalent to 9 in. of firebrick in insulating value and has 1/60 of the heat storage capacity of firebrick for the same heat flow. Full-page charts are included for determining the thickness required for hotface temperatures and for ascertaining efficiency of thicknesses.

Koppers Yearbook

The story of The Koppers Company, the industrial organization which in 24 years has quietly grown to become a producer of products for nearly every type of industry in the nation, is told for the first time in "Koppers Yearbook—1938," a new book which has just been published.

Primarily a processor of coal, the book states, the company performs all of the numerous operations necessary to obtain coke, coke oven gas, tar, light oils and chemicals which it and other industries convert into an almost countless array of products.

The book also describes The Koppers Company in the light of a taxpayer and employer.

Pipe Welding

Arc welding of piping for operation at pressures up to 1500 lb per sq in. and temperatures up to 1000 F is covered in a new 12-page bulletin issued by the Metal & Thermit Corporation. In addition to the selection of pipe materials and welding electrodes, this bulletin discusses weld design, welding procedure, preheating, stress-relieving, testing of welds and the qualification of welding process and welding operators.

Pulverized Coal

"C-E Pulverized Coal System for Direct Firing" is the title of a new 36-page catalog issued by Combustion Engineering Company, Inc. It contains a synopsis of the development of pulverized coal firing and its influence on the capacities and designs of steam generating units. The section on mills describes both the impact and the bowl mill types for direct firing. That on burners deals with tangential corner firing, vertical firing and horizontal turbulent burners. Mill feeders are also described and considerable space is given to a discussion of furnaces for burning pulverized coal. The 53 illustrations include, in addition to details of mills, feeders and burners, numerous installation views covering the application of pulverized coal to different boiler types and a wide range in size of boilers as installed in various industries throughout the country.

Pumps

Opposed impeller series pumps, in which two single-suction impellers are mounted with the suction openings facing in opposite directions toward the end of the shaft, are described in Catalog B-3, issued by the De Laval Steam Turbine Company. In this type of pump not only is the impeller balanced hydraulically, but only two pairs of wearing rings are needed, the same as for a single-stage pump. Leakage from the second stage to the first stage is reduced by a labyrinth shaft sleeve and the fact that the short, stiff shaft requires only small clearance.

Refractory Products

In a new 20-page engineering data book, Johns-Manville has made available full information on the J-M line of refractory products—including cements for boiler settings, baffles and chimneys, castables and plastics—which this company has developed to fulfill the diversified requirements of modern industrial practice. The descriptive material includes data on the character or base of each product, its highest working temperature, the number of pounds needed to set 1000 brick or form one cubic foot of construction and the form in which the product is furnished. How to apply refractory materials so as to obtain the best operating results is an important phase of the subject which the book discusses thoroughly. A valuable feature is a comprehensive table which lists separately the various types of heated equipment used in different industries and power plants.

Water Level Control

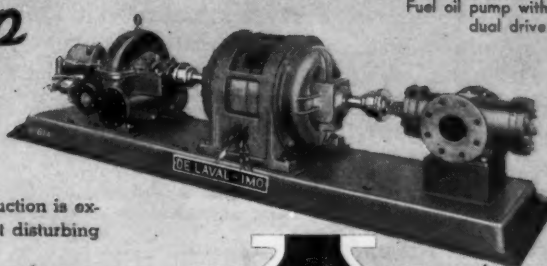
The control of boiler water level on a combined utility and sugar plant load by means of the Copes system is described by J. H. Dunlap of the Fort Bend Utilities Company, Sugar Land, Texas, in bulletin No. 413 issued by the Northern Equipment Company. The refinery steam demand in this case fluctuates from 15,000 to 165,000 lb per hr and charts are reproduced showing a practically constant water level. The unit is gas-fired and the steam pressure 450 lb.

The De Laval-IMO Pump

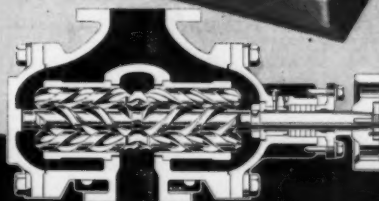
runs without vibration or pulsation at standard motor and turbine speeds.

The three moving parts are in perfect rotational balance and there are no valves, no gears, no bearings, and only one stuffing box, which is exposed to suction pressure only. The construction is exceedingly simple, and the pump can be dismantled for inspection without disturbing piping or driving motor.

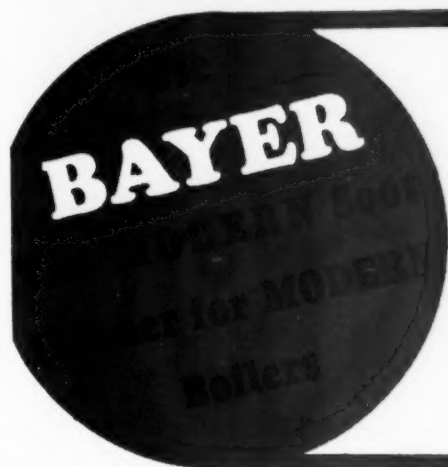
State capacity and head required, nature of drive and character of oil to be pumped, and ask for Catalog I-31



Fuel oil pump with dual drive



DE LAVAL STEAM TURBINE CO., *Trenton, N. J.*



BALANCED VALVE-IN-HEAD

provides a valve action independent of element rotation—supplies full steam pressure necessary for full efficiency in reaching and cleaning all heating surfaces in present-day boilers.

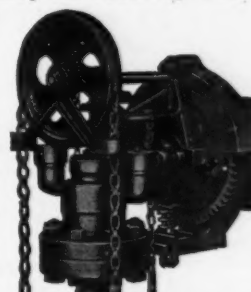
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made of austenitic high-temperature alloy have demonstrated longer low cost service life for Bayer Soot Cleaners. Write today for descriptive Bulletin No. 107

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Huge Press Installed to Bend Boiler Plate

The largest and most powerful press yet constructed for bending boiler plate has just been installed at the shops of the Hedges-Walsh-Weidner Division of Combustion Engineering Company, Inc. at Chattanooga, Tenn. This press, which has a clearance between posts of 40 ft 6 in., is capable of cold bending boiler plate of more than 6 in. thickness. As shown in the photograph reproduced on the cover of this issue, it consists of two 3000-ton four-post hydraulic presses connected by two built up beams, the upper beam being 14 ft in depth at the center and having a travel of 5 ft. Only the top of the lower beam shows in the photograph. The total weight of the beams is over a million pounds.

The two main rams are each 50 in. diameter and are operated with water pressure of 1500 or 3000 lb per sq in., according to whether the intensifier is connected to give the maximum power. On each side there are four push-back rams arranged for high-speed work and under the bottom die there are four manipulating rams for handling the work. From the floor to the top of the cylinders measures 27 ft and below the floor the equipment extends 22 ft. Many new features are incorporated, including ease of control and the placing of only the working parts above ground; the overflow and pneumatic filling tanks, intensifier, etc. are all below ground.

The press is served by a 30-ton special double trolley crane and a plate-heating furnace capable of taking plates 14 ft wide and 45 ft long.

Power Papers at A.S.M.E. Fall Meeting

The Fall Meeting of the A.S.M.E. at Providence, R. I., on October 5 to 7, will include the presentation of a number of papers of special interest to power men. Among these are:

"High-Pressure Installation at L Street Station, So. Boston" by Geo. A. Orrok, Jr.

"Discharge Temperatures from Pulverizers" by Ollison Craig

"Industrial Power Plant Steam and Power Generation" by R. D. Booth

"The Atomization of Oil by Small Pressure-Atomizing Nozzles" by E. B. Glendenning, L. H. Ventres, W. A. Sullivan and A. R. Black

"Condenser-Tube Life vs. Design and Mechanical Features of Operation" by A. J. German

"Condenser Performance with Reduced Cooling Surface" by J. H. Harlow and R. A. Bowman

"Control of Slime and Algae in Industrial Cooling Waters" by H. K. Nason and J. D. Fleming

"Industrial Evaporator Design, Application and Operation" by W. K. Adkins

"Industrial Applications of Evaporators in No. 1 Power House of the Ford Motor Co." by W. W. Dulmage

An extensive program of plant visits has been arranged and the trips have been so planned that they will not interfere with attendance at technical sessions.

Headquarters will be at the Providence-Biltmore Hotel.

Opposes Freight Rate Increase

Freight rate increases on bituminous coal in the face of falling production is contrary to all sound principles of economics, declares John Carson, Consumers' Counsel of the National Bituminous Coal Commission.

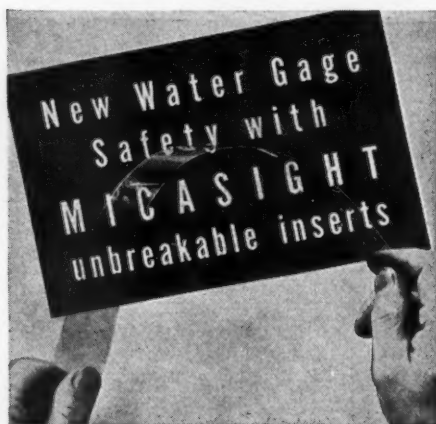
In a reply filed with the Interstate Commerce Commission, Mr. Carson requests that the petition filed by Class I carriers to make permanent the temporary rate increases on bituminous coal granted on October 19, 1937 be denied. The increases, amounting to 15 cents per ton in the West and 10 cents per ton in the East, are to expire December 31, 1938. It is estimated that this increase has forced consumers to pay 40 million dollars yearly additional for their coal and has resulted in many users turning to other fuels.

Consumers' Counsel filed a formal petition more than a year ago asking the Interstate Commerce Commission to initiate a general investigation of the bituminous coal freight-rate structure.

Robert J. Davis

The Board of Directors of The Johnston & Jennings Company of Cleveland, manufacturers of the Stowe Stoker, have elected Robert J. Davis president to succeed Tracy J. Calhoun, who becomes Chairman of the Board.

Mr. Davis has been a director of The Johnston & Jennings Company for the past two and one-half years and is a grandson of the late Robert Johnston of Cleveland, who was one of the founders of the business in 1884. Hart H. Fleming continues as vice president and H. C. Huston is sales manager of the Stoker Division.



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Don't let the efficiency of your modern power plant be marred by frequent gage glass breakage. Reliance MICASIGHTS *can't* explode. They remove the danger of flying glass—save costly damage claims and constant upkeep expense.

Mica *bends*—doesn't shatter. Securely clamped in forged steel MICASIGHT body—leakproof—special tough mica .035" thick stands pressures to 2000 lbs. Lasts 10 times as long as glass. Clear visibility for instant water level reading. Doesn't corrode, but easily replaced if dirty after long use.

MICASIGHTS for any pressure range—any visibility height. Can be illuminated for bright sharp reading.

Hundreds of MICASIGHTS in use. Add this assurance of safety and uninterrupted power. Write for folder and prices.

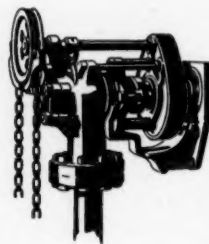
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